THE ENGINEER

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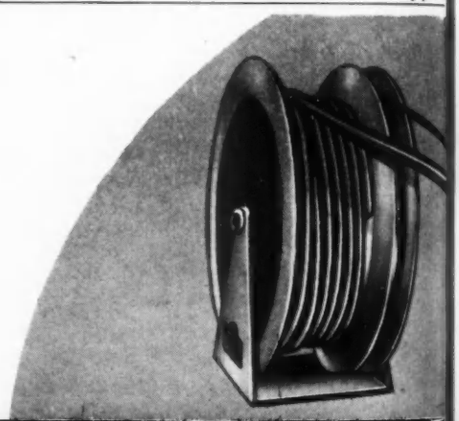

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THE ENGINEER

No. 5482 FEBRUARY 17, 1961 Vol. 211

REAPPRAISAL OF BRITAIN'S DEFENCE PROBLEM

As we go to press the year's White Paper on Defence has just come to hand. We expect to comment upon it in more detail in our next issue. Here we study the existing defence situation as we see it. Britain's decision to place Fighter Command under the control of S.A.C.E.U.R. has no obvious connection with the United States recent offer of five "Polaris" submarines to N.A.T.O. in 1963. But taken together they may well suggest a change in the coming years in the nature and strength of Britain's conventional forces and deterrent contribution. Since 1957, when it was officially announced that there is no means of adequately protecting the people of this country against attack with nuclear weapons, the job of Fighter Command has been limited to the defence of the deterrent bases. Even this limited role has now become much less important. Not only are the British V-bombers widely dispersed but they can be airborne within three or four minutes. The main threat to the deterrent bases comes from the large number of medium range ballistic rockets available in Russia for launching against this country. In any event, the menace from bomber aircraft will be more effectively countered by the earlier warning of attack made possible by the United Kingdom forming one of the four air defence regions in a unified N.A.T.O. air defence system. To the unbiased observer, however, the real significance of the placing of Fighter Command under S.A.C.E.U.R. command is the indication it gives of a more reasonable and logical view of the purpose of the "Shield" General Norstad has asked for stronger and better equipped conventional forces in Europe, ostensibly to raise the threshold at which it may become necessary to use nuclear weapons. But he is surely advancing this reason primarily to assist in maintaining the interest and enthusiasm of fifteen nations in the N.A.T.O. organisation. The idea that the Soviet leaders would embark on a major aggression in Europe without regard to the possible consequences until their armies encountered nuclear weapons on the battlefield is beyond credibility. There is, however, everything to be said for strengthening the "Shield" with conventional forces to ensure against N.A.T.O. being presented with a *fait accompli* — for example, the unexpected occupation of Berlin or other enclave of Allied territory. To strengthen the N.A.T.O. conventional forces in Europe is merely to go back to the purpose of the organisation when it was founded eleven years ago. At the same time these conventional forces could be drawn on by a nation if and when necessary to deal with a more probable campaign elsewhere.

Britain, which may well have a major role to perform in preventing a "brush-fire" campaign overseas from becoming more serious, has thus everything to gain by the transfer to N.A.T.O. of Fighter Command. Once again British fighters become an essential part of the deterrent and none can argue in the future that the country can afford to reduce the strength of this branch of forces. The essential role of the British Army — both for the "Shield" and "brush-fire" campaign duties — is well understood. Whether or not General Norstad is satisfied with the strength of the B.A.O.R. contribution to the "Shield" hardly comes into the question. The problem is governed by the practical difficulty of being able to raise and maintain an army of 165,000 men which the Chiefs-of-Staff consider necessary to meet all their commitments. Much more difficult to understand are the Government's plans for the Navy. Nearly 20 per cent of the annual defence budget has been spent on the active deterrent and its protection, which leaves little money available for a building programme to replace the large warships. Neither Parliament nor the nation, however, is yet convinced that a powerful Navy is more important than a substantial contribution to the Western deterrent to prevent a war which would mean suicide. Yet Parliament continues to approve the building of frigates — over eighty have already been built or authorised — and anti-submarine submarines. Since even *one* would be superfluous in a total war, clearly the possibility of a war on a lesser scale than total must be recognised, even if not officially admitted. It has also to be borne in mind that stocks of H-missiles are now more than sufficient for both East and West to destroy the other. Should Britain not therefore accept the American offer of five £45,000,000 "Polaris" submarines to N.A.T.O. and make a reappraisal of our deterrent commitments? France won't have them unless their missiles are under her control. To offer them to Germany would have a deplorable political effect. Britain on the other hand is already providing a base for United States submarines; American officers control the operation of the "Thor" land-based rockets and British and American officers and men are well accustomed to working together. (Indeed, for a special purpose during the war, an American was actually placed in command of a British submarine!) Would not Britain's prestige and honour as a great power and her right to influence N.A.T.O. policy and strategy be recognised if, in addition to a small number of V-bombers, she, instead of the United States, provided crews for and operated the five N.A.T.O. "Polaris" submarines, with a U.S. liaison officer on board, in view of the facilities being afforded for similar vessels under the United States flag to operate from this country? Money would then be available for a balanced naval building programme including — if considered necessary after 1970, when V-bombers are unlikely to be effective — the building of a squadron of larger ships armed with both guns and "Polaris" missiles. Having regard to the position of nuclear stalemate that has now been reached, it is surely desirable for all three Fighting Services to be able to fight a war on a scale less than total without necessarily having to depend on allies. In that case the Royal Navy may continue to require vessels armed with 6in guns or rocket-propelled surface-to-surface missiles to deal with surface ship attack on the wide ocean trade routes.

COSMIC QUESTIONS

Whether the universe began with an explosion, or whether it has had no beginning and no end, is a question which may leave some as cold as the depths of outer space. Not so the London evening papers of last Friday, whose posters enthusiastically offered an explanation of "how it all began" for the price of threepence. This was their reaction to the theory of Professor Martin Ryle, who on that day, in conjunction with Mr. R. W. Clarke, presented a paper to the Royal Astronomical Society based on observations made with the large radio telescope at the Mullard Radio Astronomy Observatory, Cambridge. Studies of very weak sources over eight years have shown discrepancies with predictions based on the steady state concept and encouraged a return to the idea of a singular moment of "creation". As if this was not enough for contemplation over the week-end, the Russians on Sunday launched an earth satellite, which then itself discharged an "automatic interplanetary station" on a flight to the plant Venus. It is expected to reach the target area in the second half of May. Possibly photographs of the surface of the planet, screened from observation by optical telescopes by cloud cover, will now be added to the views of the other side of the moon which have already been obtained by the Russians. Perhaps these events will stimulate interest in astronomy among the general public. They will have some difficulty in pursuing the study, however, because apart from the weather, the mercury and the sodium street lamps have ruined the pitch for the amateur observer. The days when the great nebula in Andromeda could be observed "with the naked eye or a good opera glass", to quote the popular astronomical works of some years ago, seem to have gone for ever. Radio telescopes and satellites notwithstanding, stellar space seems more inscrutable than before.

POWER FARMING

The tenth National Power Farming Conference held in Brighton last week emphasised clearly that the development of agricultural machinery will play an increasingly important role both in the well-being of the United Kingdom's own farming industry and as one of the "best-selling" items of our export trade. The theme of the Conference, "Power to Compete," was therefore singularly appropriate.

The tremendous expansion which has taken place in farm mechanisation in the post-war years has not been without its headaches. From the farmers' point of view the drift of farm workers from the land has not lessened the cost of labour as a factor in the farm accounts. The proportion of costs attributed to labour to-day stands at about 25 per cent of total costs as compared to 26 per cent pre-war. On the other hand the cost of mechanisation has increased from 9 per cent in 1937-38 to something like 18 per cent now. Increased mechanisation, to an engineer, almost certainly means increased production and efficiency, but to the farmer this is not necessarily so. He has to contend, as phlegmatically as he can, with the whims and fancies of Nature, and this winter, with its above average rainfall, Nature has successfully kept nearly all machinery out of the fields. Indeed, it was suggested during one of the discussions at the Conference that perhaps Hovercraft could be adapted to get implements to work where tractors would only bog down. Our impression was that although the suggestion was meant to be humorous, there was in the mind of the speaker a wistful hope that the day would come when his machinery would not bog down. The makers of tractors and other machinery might do well to look into fundamental research and practical development being done in America on the design of tracked vehicles, largely under the inspiration of Col. M. G. Bekker.

The value of tractor and implement exports for the year 1960 was £128 million compared with £105 million for 1959. Seventy-five per cent of all the tractors produced in 1960 were exported; a record to be proud of, indeed, but not one to be content with. In his opening address to the conference, Mr. J. M. A. Smith, assistant managing director of the Ford Motor Company, Ltd., warned that a free and integrated European market would not automatically make things easier for anyone. In the long run, he said, every tariff wall that comes down lets out as much as it lets in. Both industry and agriculture would have greater opportunity but both, he added, at the same time, would have greater need to equip and reorganise; greater need to compete still more effectively.

Much of the value of the National Power Farming Conference lay in the many opportunities which occurred during the three days it ran for engineers and farmers to resolve their common problems. We emerged from the Conference, as we think others must have done, with a heightened awareness of the need for engineers and designers to understand better the problems facing farmers in many lands and to exercise more ingenuity in overcoming them. In the export markets of the world they have competitors, equally worthy, and just as eager to reap the rewards that can be won. The need of the world's under-developed countries for agricultural machinery underlines the urgency of the challenge.

RAILWAY ELECTRIFICATION TROUBLES

Although Brigadier Langley's interim report on the transformer failures in the Glasgow suburban trains included a note from the consultant that no evidence had up to then been submitted linking them with the dual-voltage system, the inspecting officer said in his final remarks that "inevitably difficulties arise with such a new system." It is still possible that further studies will reveal some unsuspected phenomenon not necessarily connected with the changeover from one voltage to the other. The problem must be looked at as a whole and not only in the light of its particular manifestation on the Glasgow lines. In reporting on the Glasgow mishaps, Brigadier Langley also mentioned the failures of motors and other electrical equipment on the North East London suburban electrification of the Eastern Region, commenting that "the cause of these failures has not yet been established." This should not be interpreted as meaning that they are entirely unknown, for we believe that the contractor concerned, The General Electric Company, Ltd., has for some time been following a definite line of investigation. The company now states that the trains it has equipped ran for many thousands of miles satisfactorily when on test on 25,000V, but certain troubles were encountered when the trains entered service, which involved a substantial amount of running on 6250V. A three-car set fitted out by the company as a mobile laboratory is now running on tests between Enfield Town and Chingford via Hackney Downs, a section entirely electrified at the lower voltage and taking supplies from feeder stations at Silver Street, Bethnal Green and Wood Street.

The East London train failures are also being investigated by Brigadier Langley, assisted by Mr. E. L. E.

Wheatcroft, a member of the British Transport Commission's panel of consulting engineers. Publication of his report in due course will, we hope, settle various questions which are being asked and kill much speculation which at present can only be partly informed. The most interesting question is why similar misfortunes do not appear to have befallen the trains on the 6250V section between Liverpool Street and Southend. Two differences come to mind here. One is that this route has retained substantially the feeder system and substation locations of the previous 1500V d.c. electrification. The second is that many of the trains are "hybrids" with semiconductor rectifiers feeding normal d.c. circuits. Finally, the forthcoming introduction of Trans-Europ Expresses to run on four different electrification systems has raised the question whether the B.T.C. system is in fact unique. It can claim to be so in two respects, namely that the ratio of the two voltages is four to one and that both supplies are at the same frequency. Inter-running between the two main Continental systems involves changing between 25,000V and 15,000V at 50 c/s and $16\frac{2}{3}$ c/s respectively. In some dual-system locomotives now running, advantage has been taken of the association of the higher voltage with the higher frequency to dispense with changeover of the main transformer connections when passing from one system to the other.

NOISE

It was remarked by Schopenhauer that noise is the most "impertinent" of all forms of interruption. "With due respect for the most holy doctrine of utility, I really cannot see (writes Schopenhauer) why a fellow who is taking away a wagon-load of gravel or dung should thereby obtain the right to kill in the bud the thought which may happen to be springing up in 10,000 heads — the number he will disturb one after another in half an hour's drive through the town." The philosopher was referring here to what he described as the most abominable of all noises: "this cursed cracking of whips." He did not live to anathematise those noises which, becoming audible with the advent, in and around 1860, of the internal combustion engine have now reached an almost unbearable intensity in the neighhourhood of large airfields. Schopenhauer wrote, of course, in the days of the horse-omnibus, the wax-candle and the fire-place, but even during his time there was exhibited by Samuel Brown, on the Thames at Westminster, a paddle boat propelled by one of his "gas vacuum engines." Burning hydrogen gas, this was the first vessel powered by an internal combustion engine. No mention appears to have been made of any objectionable noise and those who witnessed the trials — they included the lords of the Admiralty — "were perfectly satisfied that, as far as the power went it was as effective and precise as steam." This demonstration took place on January 31, 1827, and the speed reached by the vessel is said to have been "from seven to eight miles per hour."

One hundred and thirty-three years later — in 1960 — the proceedings of an Appellate Committee in the House of Lords had to be suspended owing to the noise occasioned by the demonstration up and down the Thames between Westminster and Lambeth bridges of a new type of craft — the Hovercraft. The demonstration was watched with interest from the terrace of the Houses of Parliament, an interest not shared by members of the Appellate Committee! After carrying on for half an hour Lord Simonds, describing the noise as "intolerable" and not fair to counsel, adjourned the procedings. While it is the machine-made thunder from the air which is — we suppose — the most shattering noise nuisance to-day, the increase in mechanised road vehicles of all descriptions presents another noise problem which is becoming more acute. One cause is probably to be found in gross neglect of maintenance (responsible as well for the poisonous quality of the exhaust). We have all become familiar with the hideous din which can accompany the progress of a dilapidated, worn-out, ill-maintained and badly-driven lorry. In a paper submitted recently before the Diesel Engineers and Users Association, Herr Lüderitz of Klöckner-Humboldt-Deutz A.G. mentions that "In Germany the maximum noise level is laid down in the traffic regulations and every vehicle running on streets has to pass the examination of the Technical Supervisory Authorities (TUV) before being licensed." Certainly the automobile engineer has now his ally in the acoustic engineer and with the introduction of the decibel scale accurate noise measurement should be helpful not only to those whose duty it is to protect the public from nuisances, but to those whose work it is to locate and remove the causes of such nuisances. There will, however, always remain noises which can only be silenced by punitive action, as for example those set up by the mechanised morons who appear to take delight in misusing their motor-cycle or sporting-car engines without reflecting that they are annoying everybody within hearing radius. Under the Noise Abatement Act, 1960, it may prove possible to take effective action against them.

The Engineer—100 Years Ago (FEBRUARY 15, 1861)

"The Universal Private Telegraph"

"A company has recently been formed for the purpose of introducing into general use the telegraphic instruments invented in 1839 by Professor Wheatstone, and improved by him in 1858. These instruments are specially contrived to facilitate the use of the telegraphic wire as a means of communication between branch establishments throughout the principal cities and towns and in all cases where such communication may be found desirable.

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"The ends of the wire at each station, after passing through the indicator and the communicator, are brought into contact with the earth, commonly by contact with the waterpipes of the establishment. The stand of the indicator is furnished with a lever turnplate by which the alarum for calling attention can be thrown into circuit, or the wire brought into use. By means of the above instruments any person able to read and spell may receive and transmit messages by telegraph. The speed of transmission attained after a little practice is at the rate of one hundred letters per minute."

Canadian Pacific Transcontinental Trains

THEIR MOTIVE POWER AND EQUIPMENT

By EDWARD H. LIVESAY

No. I

IT has so long been customary to refer to Canada as a "new country" that the term has become almost conventional, notwithstanding that the genesis of the Dominion was contemporaneous with the settlement of Quebec by the French over 350 years ago; it is time a more appropriate designation were chosen. It will be granted, however, that development in some parts of this vast country has been fairly recent, and that for the first couple of centuries it was confined mostly to the Eastern section, extending only very slowly westward through the rugged central region, with the result that settlement of the 1500-mile expanse extending from the Great Lakes to the Pacific Coast did not really begin for another 200 years or so. That being the case, the western half of the country may be dubbed "new" with greater accuracy, yet even that admission calls for some qualification, inasmuch as its birthpangs coincided with the founding of the fur trade in the fifteenth century by Charles II and the "Governor and Company of Adventurers of England trading into Hudson's Bay." In 1745 the Company, by that time firmly established, built a great fort at Churchill, on the western shore of Hudson's Bay, of massive design, with walls 30ft thick and mounting forty-two guns. Despite its formidable character, in 1782 Hearne, the Governor, meekly surrendered it to the French Admiral La Perouse without attempting to defend it, the victors destroying it; the ruins still lie much as they were left in those far-off days. Churchill is now the northern terminus of the Hudson Bay Railway, a branch of the Canadian National Railway, over which considerable wheat is shipped during the four or five months the Bay is open to navigation. In the light of this, and many other evidences of early colonisation, it will be seen that the West is older than most people realise.

So much for history. Coming to the present, and transportation, with which this article is chiefly concerned, that too goes farther back than one would think—railway transportation, at any rate. The first transcontinental train left Montreal over the recently completed Canadian Pacific Railway seventy-four years ago, and a daily service in both directions has been maintained ever since. The route followed was much the same as it is to-day, though there are slight variations here and there, due to improved location, chiefly at the two ends, and in the Mountains. This is the case between Montreal and Ottawa in the East, and in the extreme West, where originally the terminus was at Port Moody, near the head of Burrard Inlet, 13 miles short of the present terminus at Vancouver. That great city only began its growth with the coming of the railway; at first, pointlike, it had position but no magnitude; now it has both. It is difficult to give its population with any accuracy, when every day shows an increase, but it is safe to put it at over 600,000. Since the early days, minor route deviations have come about, such as in the Rockies, where the "Big Hill" down the Kicking Horse Pass has been eliminated by the Field Spiral tunnels, and the Roger's Pass zig-zag down the western side of the Selkirks has disappeared as a result of the construction of the 5-mile Connaught tunnel. These changes and improvements have reduced the distance between Montreal and Vancouver from 2900 miles to 2881; Port Moody has become a mere "flag stop," and the transcontinental trains now come to a final halt at Vancouver, near the sole entrance to the magnificent harbour, one of the finest on the shores of the Pacific, the target at which the railway aims right from Montreal.

The inaugural through train (No. 1), the "Pacific Express," was made up of several mail and baggage cars, coaches and "Colonist" sleepers, plus a dining-car, "Holyrood," and two first class sleeping cars, "Yokohama" and "Honolulu," headed by a 4–4–0 type engine (Fig. 1), one of a dozen which were needed to cross the continent, most being of this classification, though 4–6–0s were used through the mountains. The accompanying timetable gives the schedules of the four trains providing services over the years from 1886 to 1960, and shows the steady development that has taken place.

In the course of time, as the track improved and engines became more powerful, the schedule of the "Pacific"—and that of the "Atlantic," the corresponding eastbound train—improved considerably until, on the inauguration of the "Dominion," transcontinental timing became more or less static, and remained so for several years. However, with the introduction of the "Canadian" in 1955, it was finally cut by over seventeen hours, this substantial reduction being achieved not so much by faster point-to-point running necessarily as by cutting out all the less important stops, both regular and "flag," and reducing station time at divisional points, where previously the steam locomotives had to be serviced, which might take fifteen or twenty minutes, whereas the diesels can be watered and the crews changed, in a matter of five minutes. At the big centres such as Fort William, Winnipeg and Calgary, the forty-five to sixty minute halts previously the rule have been reduced to fifteen, and "flag" stops eliminated entirely. This has raised the average speed right across the continent, stops included, to over 40 m.p.h., which is really very creditable considering the distance covered, 2881 miles, the severity of much of the route, and—in winter—the climatic conditions that may have to be fought through. For seven months out of the twelve semi-Arctic or actually Arctic weather may be met with; the temperature may fall to 60 deg. below zero, equal to 92 deg. of frost; blizzards may rage, coupled with snow-slides, wash-outs, and other hazards in the mountains. Well acquainted as I am with Canada, and have been for half a century with the country's railways, their safe and dependable operation despite all these handicaps impresses me as much as ever.

It is probable that the average speed of the "Canadian," 40·72 m.p.h., could be raised if it were considered advisable or worthwhile, as most of the prairie stretch between, say, Whitemouth, a little east of Winnipeg, to Calgary, 886 miles, is quite suitable for really fast running, as also are other sections, some of which are double

TIME TABLE

	"Pacific," 1886	"Imperial, Ltd.," 1900	"Dominion," 1930	"Canadian," 1960
Montreal	dep. 8.00 p.m. Monday	dep. 9.30 a.m. Monday	dep. 8.00 p.m. Monday	dep. 2.15 p.m. Monday
Ottawa	11.45 p.m. Monday	1.25 p.m. Monday	10.10 p.m. Monday	4.15 p.m. Monday
North Bay	9.10 a.m. Tuesday	8.55 p.m. Monday	4.35 a.m. Tuesday	10.10 p.m. Monday
Sudbury	12.10 p.m. Tuesday	—	6.35 a.m. Tuesday	12.40 a.m. Tuesday
Port Arthur	4.00 p.m. Wednesday	—	—	—
Fort William	—	6.55 p.m. Tuesday	12.15 a.m. Tuesday	2.25 p.m. Tuesday
Winnipeg	9.40 a.m. Thursday	7.15 a.m. Wednesday	8.20 a.m. Wednesday	10.25 p.m. Tuesday
Broadview	7.40 p.m. Thursday	2.24 p.m. Wednesday	3.55 p.m. Wednesday	3.38 a.m. Wednesday
Regina	—	—	5.10 p.m. Wednesday	4.20 a.m. Wednesday
Moose Jaw	2.00 a.m. Friday	6.42 p.m. Wednesday	6.40 p.m. Wednesday	5.10 a.m. Wednesday
Medicine Hat	2.20 p.m. Friday	3.05 a.m. Thursday	1.40 a.m. Thursday	9.59 a.m. Wednesday
Calgary	10.50 p.m. Friday	6.40 a.m. Thursday	6.20 a.m. Thursday	1.20 p.m. Wednesday
Revelstoke	4.05 p.m. Saturday	9.35 p.m. Thursday	5.05 p.m. Thursday	9.30 p.m. Wednesday
Port Moody	arr. 12.00 noon Sunday	—	—	—
Vancouver	—	arr. 1.00 p.m. Friday	arr. 8.00 a.m. Friday	arr. 10.00 a.m. Thursday
Total time	136 hours	97½ hours	84 hours	67·45 hours
Miles	2,900	2,881	2,881	2,881
Running time	139 hours	100·5 hours	87 hours	70·45 hours
Average speed	20·86 m.p.h.	28·8 m.p.h.	33·19 m.p.h.	40·72 m.p.h.

The total times given above make no allowance for the putting back of clocks one hour at Fort William, Broadview and Field when going west, to Central, Mountain and Pacific time respectively, so three hours must be added to the figures if the actual running time is taken into account when working out the average speed.

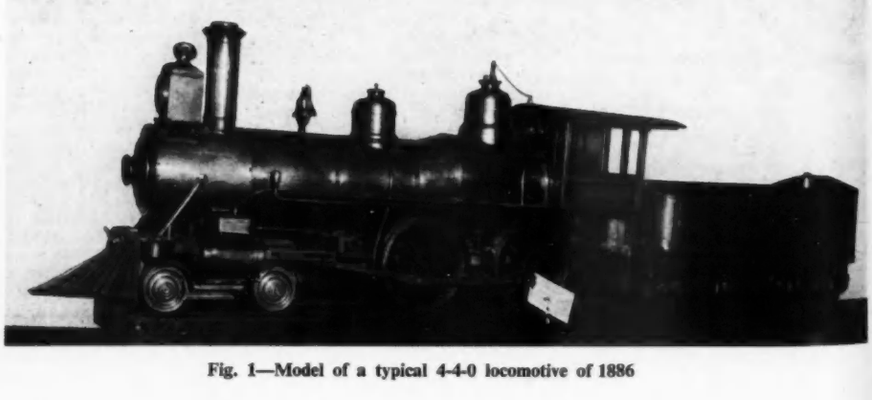


Fig. 1—Model of a typical 4-4-0 locomotive of 1886

track. But for various reasons it would be inexpedient ; for instance, it would increase the risk of accidents at the innumerable level-crossings, most of which are not even gated, due to fools trying to " beat the train to the crossing "; the number of these congenital idiots seems to increase at a ratio corresponding to the number of cars. Incredible though it may appear, quite a number of accidents at level-crossings are the result of cars running into the *sides* of trains ; it looks as though some drivers are determined to hit or be hit somewhere, rather than miss the cavalcade altogether. I have seen from the cab things done by drivers that for sheer asininity approach the unbelievable, such as the following. By law, a tank-truck must come to a stand before crossing a railway track, a very sensible regulation, which no responsible person would wish to flout, at any rate when a train is approaching at high speed. I was in the cab of the " Chinook," a fast train running between Calgary and Edmonton, travelling at about 75 m.p.h. when a big tank-truck was seen nearing a crossing a few hundred yards ahead. Instead of stopping as it should have done, and as we in the cab naturally expected, it was driven deliberately and leisurely right across—we missed it by about 25ft, and a second or so. Very possibly it was loaded with gasoline, and had it been hit—but there's no need to enlarge on what would have happened. I looked at the enginemen—there was no need for *me* to say anything—their comments were fully adequate. In the face of that sort of thing the law is no protection—one is at the mercy of a criminal lunatic.* It is easy to say " Do away with the level crossings," which is the obvious solution, and may come about some day, but meanwhile there are many, many hundreds of these unprotected hazards between Montreal and Vancouver, so the company is wise in being satisfied with an average speed of 40·72 m.p.h. for the " Canadian."

Plotting the schedule for the new and faster " Canadian " right across the continent proved difficult. It was not merely a matter of speeding up the train by cutting so many hours from the overall time, which would have been comparatively simple ; it involved the important factor of so timing arrival at widely separated major towns that this would take place at reasonably convenient hours, which could not always be managed where such great distances are concerned. Regina, for instance, the capital of Saskatchewan, is reached at 4.20 a.m., not an ideal time, but nothing could be done about it without further dislocation elsewhere, though no doubt the Chamber of Commerce drew attention to the matter, claiming in effect " You can't do this to us ! " But it had to be done. Other towns affected in the same way are less important centres, being basically divisional points with an agricultural setting ; most night stops in the New Ontario lake district, and in British Columbia, are at indisputable railway towns.

It will be noticed that the inaugural " Pacific Express " stopped at Port Arthur, where time changed, whereas now both stop and change take place at Fort William, the divisional point ; the two cities are about 5 miles apart. The explanation is, I believe, that soon after the railway had been built through Port Arthur, strained relations developed between the City Fathers and the Company—real estate matters no doubt being at the root of it, with taxation as the runner-up—with the result that the C.P.R. solved the dispute by pulling up stakes and shifting its headquarters 5 miles to the west and founding a new town which was named Fort William, leaving Port Arthur lamenting. The two towns remain rivals to this day, but the latter ultimately became the Canadian National Divisional point. With regard to Regina, which does not appear in the " Pacific's " timetable, the place did not exist in 1886 when the railway first went through, except as a mere shack-town known as " Pile o' Bones," only later expanding and finally blossoming into the capital of the province. Though it never became a divisional point, being roughly midway between Broadview and Moose Jaw, Regina has become a considerable railway centre, several lines radiating out from it in different directions. The city was struck by a cyclone in 1911, which did a great deal of damage, and killed over a hundred people. In those days statements were often made in official publications stressing the manifold advantages of prairie settlement, but carefully avoiding the mention of the drawbacks, to the effect that cyclones were unknown in the West, whereas anyone who has lived there any length of time knows the contrary; they occur somewhere in this vast open country probably every year. The saving grace is that centres of population are so far apart they are seldom hit as was Regina, and cyclones in open country do not get corresponding publicity. I myself was involved with a near-cyclone, a good imitation of the real thing, on one occasion ; it was not an experience I would care to undergo again.

[Fig. 2—No. 5935, 2-10-4, the last Canadian-built steam locomotive

One's feeling of utter helplessness in the face of an elemental force is nerve-racking, the sensation being intensified by the removal of half one's roof, further strengthened by expectation of the imminent disappearance of the remainder. So much for the genesis and operation of the Canadian Pacific Railway over a matter of sixty odd years, with steam the motive-power, but in Canada, as in so many other countries, the day of the steam locomotive is over. This article will describe its successor, and how it solves the problem of transporting the passenger in comfort, within a reasonable time, over 2881 miles of very varied terrain—if the said passenger is not in too great a hurry. In that case he flies, seeing nothing, doing nothing but sitting in a seat, probably sleeping, but admittedly " saving time "—so he will have more to waste at the other end. However, being wiser, I travel by rail, on the " Canadian " or " Dominion," and I hope shall find the journey more interesting.

A decade or so ago, large-scale operation of diesel-electric locomotives in the United States, and to a lesser extent in Canada, led both the Canadian Pacific and Canadian National Railways to the definite decision that a complete change-over from steam to diesel-electric motive power was justified, and that the time had come to make it. In 1949, therefore, the Canadian Pacific Railway built its last steam locomotive, No. 5935, 2–10–4† (Fig. 2), which joined the others of

† Coincidentally the last steam locomotive built for British Railways also happens to be a ten-coupled freight engine, " Evening Star," recently turned out at Swindon. Fortunately its life is likely to be considerably longer than was that of No. 5935—twenty years ?—E. H. L.

Fig. 3—A fine view is obtained from an observation dome

* To give point to the above, not long ago the Sante Fé " Chief " was wrecked near Bakersfield, California, through hitting a tank truck that did not stop—fourteen dead.

Fig. 4—Interior of Canadian Pacific stainless steel coach

its class on duty in the Rocky and Selkirk mountains between Calgary and Revelstoke, handling passenger trains, such as the "Dominion," and freight, over the two divisions. But the writing was on the wall; No. 5935 and the other thirty-five engines of the same class, which for many years had done fine work in the mountains, the heaviest section of the entire main line, were not destined to remain much longer in the environment they had made peculiarly their own, and the same thing now applies to all steam locomotives in British Columbia, in fact in Canada; all have now reached the point of no return—the scrap heap.

In the winter of 1950–51 successful experimental running took place over sundry stretches of the main line, particularly north of the Great Lakes, to find out, among other things, the effect of severe cold on the working of diesel-electric engines, temperatures as low as —60 deg., or 92 deg. of frost, being experienced during most winters in Central and Western Canada, with even lower figures a possibility. During these tests the "Dominion" was worked through the mountains to Vancouver by a three-unit, 4500 h.p. engine built by General Motors, and no trouble was experienced despite the exceptional severity of the weather; 58 deg. below zero was experienced at Banff, in the Rockies, probably the lowest temperature ever recorded there, quite extraordinary.

The next definite step was taken in 1953, when partial replacement of steam by diesel power was made between Revelstoke and Calgary, soon followed by extension westward to Kamloops, the next divisional point; that is, over the heaviest three divisions on the company's system. Finally, in 1954, complete withdrawal of steam power from transcontinental trains right across the continent took place, the "Dominion" and other trains becoming diesel-hauled after sixty-eight years of steam operation. No. 5935 and all engines of the same class, together with sundry other types used as "pushers" to lift heavy trains over the steep mountain grades, became "redundant," were withdrawn from their old environment, and for a brief period worked freight trains over the prairie between Calgary and Swift Current. It was the end of an era; their obituary was published in THE ENGINEER in November and December, 1951, a trifle ahead of the actual interment, and mine was the depressing task of writing it.

In 1953 the Canadian Pacific directors decided that not only should the motive power be revolutionised, but the passenger accommodation as well, and the adoption of diesel engines became associated with the introduction of rolling stock more in harmony with modern trends. The advantages of this had been demonstrated in the United States, beginning with the pioneer train, the "Burlington Zephyr," made up of stainless-steel cars built by The Budd Company of Philadelphia, and introduced by the Chicago, Burlington and Quincy Railroad in 1936. This train is still in excellent condition; during one thirteen-year period it covered 4,500,000 miles, averaging 370,000 miles per year before receiving its first shopping. In 1953 an order for 173 of these stainless-steel cars was placed by the C.P.R. with the Budd Company, of various types, thirty-six being "dome" equipped; that is to say, fitted with a twenty-four-seat glass dome (Fig. 3) raised above the roof-line of the car, giving all-round observation facilities, a considerable improvement over the usual rear-end observation car. All these 173 cars—buffet, sleeper, diner and coach (Fig. 4), the last equivalent to 2nd class non-sleeper coaches in Britain—have many new features, both as regards construction and the accommodation they provide. One original type, baggage-dormitory, has sleeping quarters for the dining-car crews. The cars were of the following types:

Eighteen dome-lounge, weighing 64·5 tons in running order.
Eighteen buffet coaches weighing 66 tons in running order.
Thirty coaches weighing 65 tons in running order.
Eighteen diners weighing 61·4 tons in running order.
Seventy-one sleepers weighing 62·7 tons in running order.
Eighteen baggage-dormitory weighing 54·5 tons in running order.

These figures show how much lighter the new type of car is than the previous wood-steel pattern, which often exceeded 70 tons, and ran on twelve wheels; the Budd type is eight-wheeled. A train of conventional cars weighs 18 per cent more than one of the latest pattern. The new cars are built to standard dimensions: length 85ft, width 10ft, height 15ft 10in to the top of the dome, and 13ft 6in to the roof of all other types, not dome-equipped.

The Budd car differs from the conventional type in being built as a hollow box-beam, with the roof acting as the load-carrying top chord, the floor as the bottom chord, the side walls as vertical shear-carrying members, and the end frames supplying torsion stiffness. Fig. 5 shows the main features of this construction. The roof is made in one piece longitudinally, of corrugated sheeting, with the two heavier longitudinal purlins welded to collision posts at each end. The side frames are modified plate girders, with the floor built as a horizontal plate girder welded to longitudinal side and centre sills. The floor is made of 4in "Z"-shaped transverse members at 10in centres, the bottom flanges being welded together to form a continuous weather-excluding surface and floor-girder. Welding is employed throughout, the whole structure being almost monobloc, of great strength, so that in the event of collision, telescoping and the stripping away of roof and walls is impossible. These cars are not only stronger than the conventional pattern, but considerably lighter, and repair and maintenance costs are very much reduced.

The running gear also shows considerable originality; the four-wheel trucks have 6in by 11in roller bearings, single equalisers, with coil springs to both bolsters and equalisers, and shock-absorbers damping out vertical bolster action. Disc brakes take the place of the previous shoe-rim type, giving smoother and faster retardation, acting by means of compound shoes gripping each side of air-cooled discs mounted on the inside hub of each wheel, as shown in Fig. 6. These disc brakes not only give better action, but have longer life, and do not overheat; they are also lighter than the

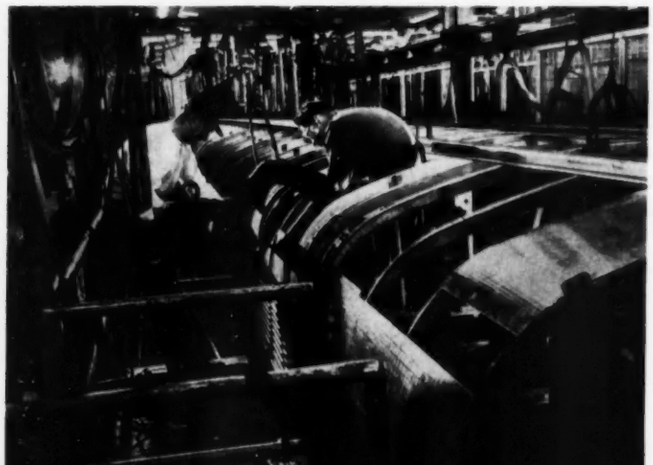


Fig. 5—Frame construction of Budd-built stainless steel coach

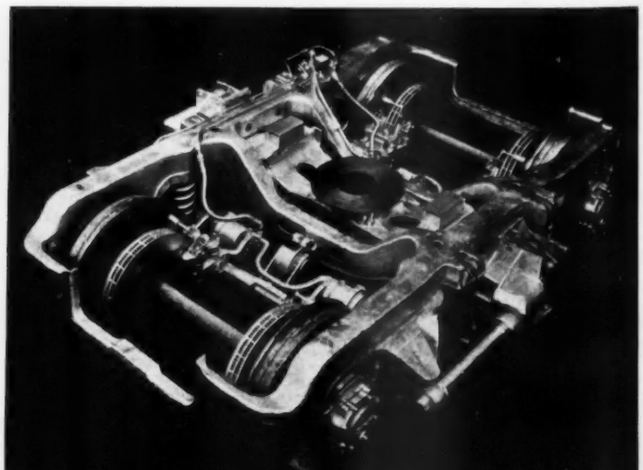


Fig. 6—Bogie of typical coach; notice the disc brakes

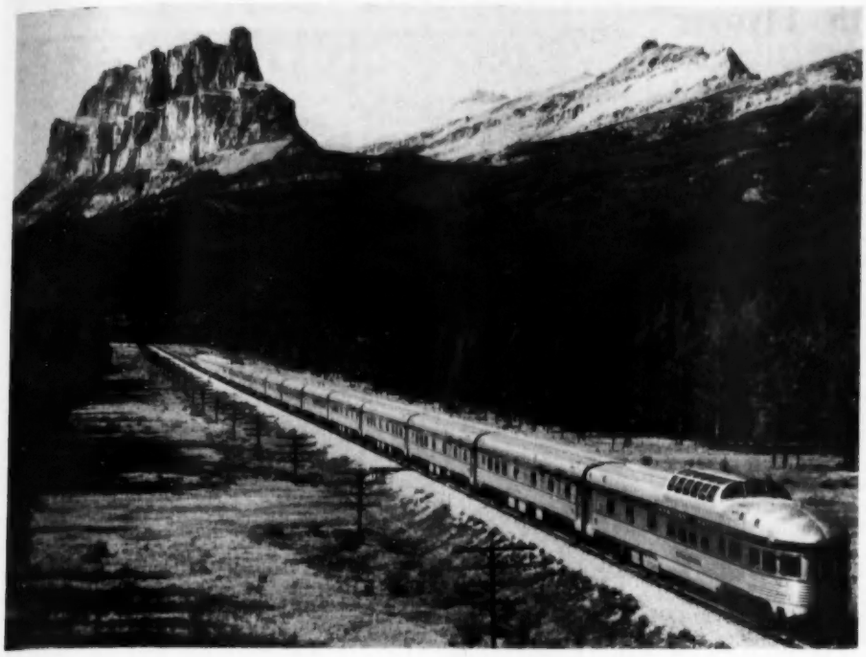


Fig. 7—The " Canadian " at Mt. Eisenhower, in the Rockies

wheel type to the extent of 1 ton per car. The trucks have 24in central bearing pivots, and four brake cylinders in pairs both sides of the transoms, operating tongs that clamp the composition brake shoes on both faces of the cast-iron disc, which has built-in vanes separating the braking surfaces to dissipate heat rapidly. In addition, a hand brake is provided at each end of the cars, acting on two discs of each truck, capable of holding a loaded car on a 1-in-10 gradient if both hand brakes are applied. No speed governors are needed with disc brakes to reduce pressure as the speed falls, due to the uniform friction at all speeds of the composition shoes, but skidding of wheels can, of course, occur, and to prevent this the "Rolokron" anti-slide device was designed and fitted very shortly after the first disc brakes came into use. This apparatus counteracts the sliding of wheels and the consequent development of flats ; it is mounted on an adapter fixed to the journal-box at one end of each axle. It controls both acceleration and deceleration exceeding 16 m.p.h.p.s. when wheel-slide occurs. An inertia switch closes and releases the brake on both sides of one truck through relays and a solenoid valve so that after an interval of three or four seconds the brake again takes hold. It is unlikely that more than a limited number of axles would be expected to have adhesion troubles at one time, so that the effect of a corresponding number of brakes being " off " has only a small result on train deceleration.

Tightlock couplers eliminate slack between cars, preventing the objectionable jerks and shocks that occur when " one car at a time " starts are made by steam locomotives ; there is also less noise from loose coupler-gear, and sound-reducing pads are placed at important points to ensure quiet running. Body-roll is reduced by utilising outside swing-hangers on the trucks, and all cars are air-conditioned in association with blower-induced ventilation.

Ample water supply for drinking, cooking, washing, &c., is contained in stainless steel tanks hung below the centre of the car, with a capacity of 300 gallons—500 gallons on the diners.

The low-pressure heating is designed to give adequate warmth when the outside temperature may fall to 60 deg. below zero, large areas being thermostatically controlled, with individual controls in smaller spaces. A system of panel-heating in conjunction with floor-heating has been arranged in which warmed air rises behind the wainscot, emerging behind the windows and passing over the glass, preventing any possibility of cold being felt from the window panes. A public-address system enables the conductor (guard) or other officials to make station or other announcements, and music can be turned on from tape-recordings. Electrical power is supplied from axle-driven generators to multi-cell batteries, motor-alternators providing current for the fluorescent lighting, vacuum-cleaners, air-filters, radios, razor-plugs and the P.A. system. From all this it will be seen how very complete the equipment is, and how much has been done to make three-day transcontinental journeys pleasant and comfortable, to an extent impossible on the older trains, good as these were, and still are.

The " Canadian " train (Fig. 7), introduced in 1955, is made up entirely of these cars, and runs in both directions between Montreal and Vancouver, via Ottawa ; a separate section, starting from Toronto, joins the through train at Sudbury, which covers the distance between the terminals, 2881 miles, in 70·45 hours, seventeen hours less than the previous " Dominion " time. To maintain a daily service with the " Canadian " between these cities in both directions calls for seven complete sets of cars, each train consisting of fourteen vehicles, namely : one coach, one dome-buffet, three tourist sleepers, one diner, seven other sleepers of more elaborate class, one being of the dome-lounge pattern, and one baggage-dormitory. The weight of these trains is 850 tons (long), and with passengers, baggage, express (parcels), &c., 950 tons or more. The older " Dominion " trains are now made up largely of the new cars, but their schedule has not been changed.

These trains are unique in several respects, so far as Canada is concerned ; among their distinguishing features is the " Gyralite," a beam of light directed vertically upward, mounted on the leading diesel unit, in addition to the usual headlight lighting up the track ahead. The " Gyralite "—to quote the company's picturesque description—" writes the ' Canadian's ' name in the sky as well as on the rails," from dusk to dawn, the white beam describing a circular sweep, quite spectacular, especially on a dusky night when the beam is reflected back from a cloud-canopy. The idea came from the States ; it was mentioned in my account of a run on " The 400," a streamlined diesel-electric train running at 110 m.p.h. on the Chicago North-western Railway between Chicago and Milwaukee, the description appearing in THE ENGINEER, September 27, 1940. The article is not at hand for reference, but if my memory is correct, the " Gyralite " did not project its beam upwards, but waved in figure eight manner from side to side across the track. But whichever the direction, it is a good way to give additional warning to " fools beating the train to the crossing," particularly when its approach is concealed by cutting or curvature.‡ The Canadian National Railways hand controlled headlight always seemed to me a good and logical device ; one which could be kept trained on the track by the engineman notwithstanding curvature, where a fixed headlight would miss the right-of-way altogether, just where it is most wanted ; this device was particularly useful in British Columbia, with its sinuous track and innumerable rock cuttings. I do not know whether the arrangement is still in use on the C.N.R. now that the company is also " dieselised," or whether it has adopted the " Gyralite "—I doubt it.

(To be continued)

Technical Report

Studies in Composite Construction. Part III : Tests on the New Government Offices, Whitehall Gardens. Natural Building Studies Research Paper No. 28. H.M. Stationery Office. Price 8s. 6d.—This report is the first in the Building Research Station's series on composite construction to deal with a field test on a whole building in course of construction. Since the test was primarily concerned with the interaction of the beams of the steel frame with their concrete encasements and the adjacent floor slabs, the paper is closely related to Research Paper No. 22, " The interaction of floors and beams in multi-storey buildings," which dealt with a similar subject analytically. A preliminary paper, which included a discussion of the test observations in relation to the analyses reported in that paper, was published in the preliminary volume of the Conference on the Correlation between Calculated and Observed Stresses and Displacements in Structures, held at the Institution of Civil Engineers in September, 1955. A more detailed account is now given in this report, with the chief emphasis placed on presenting as full and as representative a selection as possible of the observations, though the selection is still only a small part of the complete record. Such observations have an intrinsic value beyond that of any deductions from them, the Director of Building Research affirms, and may have a significance in relation to methods of analysis and design which will only be appreciated in the light of further knowledge. Their significance in relation to present methods of analysis and design is, however, discussed, and certain tentative changes in the latter are suggested.

The main sections of the report include a description of the building, followed by an account of the instrumentation, a description of the tests, and sections on the test observations, the accuracy of these observations, and a discussion of them.

‡ Since the above was written, I have been able to consult the article, quoting : " Darkness brought the headlights into play ; th re are two, as the figure shows (in front, one above the other). The lower is the usual fixed pattern, but the other is a ' Mars,' which swings the beam continuously from side to side of the track in a ' horizontal figure-of-eight ' manner. It is intended to attract extra attention, and make people realise something out of the ordinary is coming." From this, penned twenty years ago, it appears that the two headlights, both directed ahead, one fixed and the other 'figure-of-eight ' have now been separated, and one directed upwards, with no doubt better warning effect.—E. H. L.

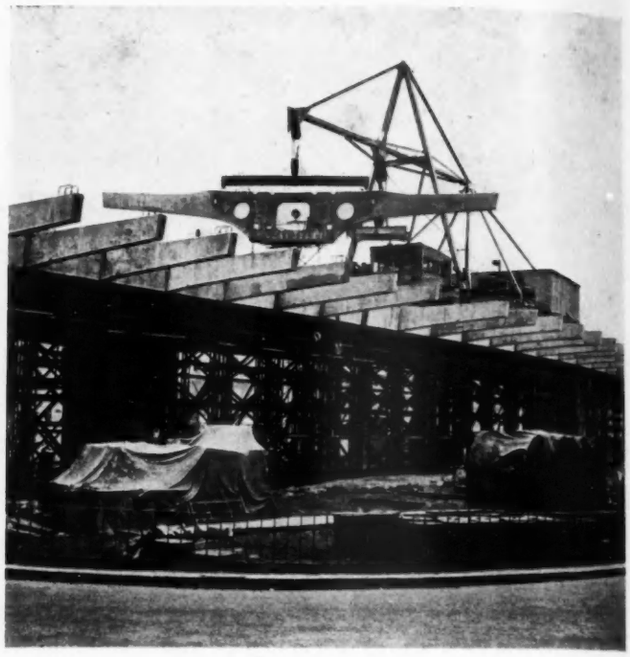
Progress of Hammersmith Flyover

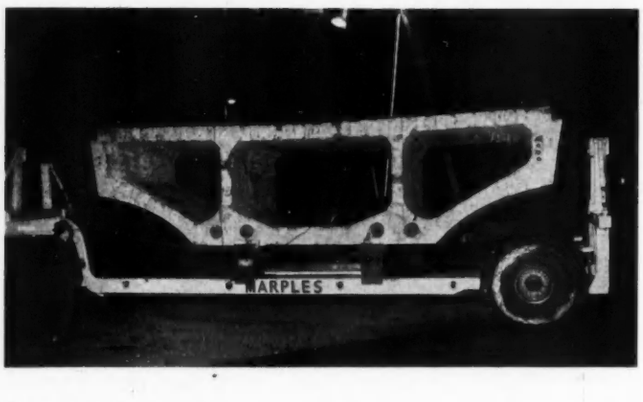
Construction of the Hammersmith flyover has now been in hand for a year, and is due to be completed by the end of this year. It consists of a viaduct of sixteen spans, mainly of 140ft (less at each end) with a total length of 2831ft (2043ft of suspended structure), carrying two 24ft carriageways. The site is extremely congested and the six roads and railway which the flyover crosses have all to be kept open throughout the period of construction. The somewhat onerous design conditions have led to a design which promises to be outstanding, both on account of its engineering features and its architectural elegance.

The flyover is carried by single columns placed centrally under it ; it is built of large precast concrete elements, cast off the site, and placed from one end on to steel trestle falsework by a gantry travelling on rails laid on the length already constructed. There are three main kinds of precast element, namely the hollow diaphragms, which form the cellular 26ft wide spine beam of the flyover, the cantilevers, which are interposed between them, and the deck slabs, which are placed on the arms of the cantilevers. These precast elements are heavily reinforced, and are of high quality concrete. The heaviest piece is the diaphragm element over a column, which weighs nearly 60 tons ; the deck slab element weighs about 6 tons.

Stranded wire cables, 1⅛in in diameter, are used to prestress the spine beam using the Gifford-Udall system. A cluster of sixteen cables passes on each side of each of the two inner longitudinal walls (or in ducts in the bottom flange at mid-span) of the spine assembly. The prestressing force is about 60 tons per cable, and about 4000 tons in the cross section. The structure is continuous (except for one expansion joint) and the prestress is applied in two stages in any one span, before and after the next span is constructed respectively. Each cable extends over two spans, passing over saddles at each third point and at the columns. Thus the first stage of prestressing provides the continuity with the preceding span, and the second stage with the succeeding one.

The columns are cast *in situ*. Transverse and vertical prestressing is applied at the columns by Lee-McCall bars—twenty-four and six bars vertically and horizontally respectively, all of 1¼in diameter. Each column is carried on two bearings. A single roller in each of these bearings measures 31·5in long and 7·87in diameter, and takes a working load of nearly 1000 tons. The columns are jacked at bearing level ; this is done to counteract any settlement (since a column initially unloaded is joined on to a structure which is already continuous) and to lock in a small hogging moment to counteract the " parasitic " moment induced by prestressing. The joints between the main elements are of fine concrete 3in thick ; cast-*in-situ* edge beams complete the main structure.





Fences strong enough to prevent a vehicle falling off the flyover, even after a severe impact, are to be constructed. The carriageway surface will have heating elements built into it to avoid ice in winter. Several research studies are being carried out to determine various aspects of the behaviour of the structure.

The first, short span of the flyover is free of falsework in the lower view. The centre view shows a diaphragm element ; 202 diaphragm and 202 cantilever elements are required, plus 408 carriageway slabs. At the casting yard at Heston, special plant is used for lifting and handling the elements. The rail-mounted gantry used at the site is shown in the upper view, carrying a cantilever element. The lifting point for the heavier diaphragm elements can be seen on the gantry. Consulting engineers to the London County Council : Messrs. G. A. Maunsell and Partners. Contractor : Marples Ridgeway and Partners, Ltd.

Automatic High-Speed Paper Coating Machine

To increase the output of "Aerocote" art paper Brookgate Industries, Ltd., a member of the Reed Paper Group, has installed a new high-speed coating machine which is designed to achieve matching of both sides of the paper in a single operation. This 85in machine can produce a variety of coatings, ranging from low weights up to 280 grammes per square metre. The initial production speed is 800ft per minute but the machine drives are suitable for higher speeds. We give a brief description of the coating preparation plant, which is fully automatic, and of the coating machine with its sectional drive and speed control system.

A NEW high-speed paper coating machine, designed to ensure that both sides of the paper are matched in a single operation, has been installed by Brookgate Industries, Ltd., a member of the Converted Products Division of the Reed Paper Group. This machine makes "Aerocote" art paper upon which many books and periodicals are printed. It is capable of producing a wide range of coating papers from low weights up to 280 grammes per square metre. It is equipped with extensive instrumentation and is designed for an initial production speed of 800ft per minute but the main equipment and drives are engineered for a future speed increase.

In particular the coating preparation plant, which is fully automatic, is claimed to be the most modern of its kind in the world.

The need for a constant standard of coating mixtures has been met by the installation of an automatic control system, housed in a central control cabinet (illustrated) which includes a graphic panel that continuously records the condition of mixes. The control cabinet and panel consists of a number of "Flexi-timers" (one for each mixer) on which formula/time combinations can be set, all controlled by two master-timers. The plant can be operated as two separate preparation "lines," to allow flexibility of colour.

Variable preset self-resetting meters control the volume and/or weight of water, steam, clay, adhesives, and various additives, both fluid and solid. These meters are actuated, via relays, by the timers, provided that optimum requirements, such as temperature, level, &c., have been signalled back to the timers by the pertinent mixer instruments. Electrical signals from the "Flexi-timers" operate solenoid-air valves, which in turn actuate process-valves, pumps, conveyors and other equipment.

Chemicals are delivered in bulk, with the exceptions of china clay and adhesives which arrive in paper sacks and bulk stores. There are two separate conveying systems, one handling china clay at any rate up to 7 tons per hour, and the other handling adhesives at rates up to 3 tons per hour. Both systems are automatic once the sequence is started from the control panel.

China clay, in paper sacks, is carried on chain conveyors to a bag slitting device which continuously slices the bags and ejects the contents into an aerated hopper. The hopper feeds a low-pressure air conveying system, whereby the clay is transferred to a cyclone separator mounted above a rotary valve on a bifurcated delivery chute, thus enabling clay to be delivered to the automatically selected mixer. The exhauster is driven by a 35 h.p. motor in the loading bay and the cyclone separator is on the preparation floor involving a vertical lift of 30ft and a distance of 200ft.

The adhesives are also delivered in paper sacks which are taken by conveyor to a 2-ton bulk storage hopper, feeding into a second hopper attached to an automatic weighing machine. The contents of the weighing hopper are automatically discharged into a second conveying system and delivered 200ft away by a cyclone above a multi-way chute, enabling the adhesives to be automatically delivered to any of the boiling vessels. The exhauster for this system is driven by a 25 h.p. motor. All the valves are operated by compressed air and controlled by solenoids and the operations are initiated from the central control panel.

The mixing and auxiliary equipment which is in contact with the coating mixture, is of stainless steel, all the items being designed for easy cleaning. After premixing of the main clay-coating, other bulk stored chemicals are metered into the mixture, again under the control of the Taylor "Flexi-timers." Elliott load-cell equipment is used for those chemicals added by weight.

When coating is required on the machine, Foxboro tank-level transmitter signals are used to start-up 3in transfer pumps, which refill machine tanks via 48in diameter Boughton gyratory screens incorporating 200-mesh stainless steel screens. Machine and storage tank agitators are automatically started on a "rising level" and stopped when the Foxboro level indicator records "empty."

The electrical starting equipment for all the preparation plant is separately housed away from moisture and dust, and the multi-starter boards (Belmos and English Electric) have individual lock-off switches to give safe access to all equipment.

The walls of the preparation "kitchen" are fully tiled in glazed light mushroom and the floors are of non-slip smooth concrete, to form a pleasant working area, which is easy to keep clean. Installation work was by Brookgate Industries' own staff, together with Coppas International, who assisted with commissioning.

Coating Machine

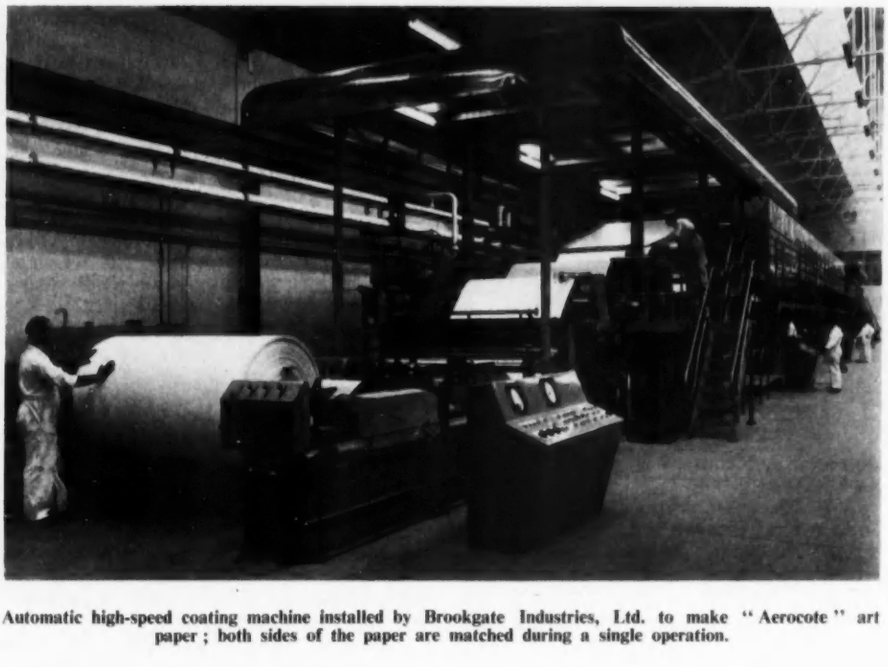
The machine has been designed to promote cleanliness and is completely hooded in polished aluminium, which also prevents condensation.

There are six main sections in the coating machine: they are the flying paster unwind equipment, the coating heads and ancillary equipment, the flying rewind equipment, the air drying equipment, the cylinder drying and conditioning plant and the sectional drives and control equipment.

Reels of "body-paper" or "raw-stock" are brought to the flying paster unwind equipment by a special forklift electric truck. The flying paster is a rotary two-spindle device, which ensures that the leading edge of the new reel is joined to the web of the expiring reel. This joint must be made at the running-speed to minimise the need to trim machine and coating head settings. The spindle drives are synchronised to the sectional main drive and all actuations allow for variable tension control.

The paper passes from the unwind and tension control to special coating heads, enabling the coating mix to be applied by various roll-coating methods and/or roll-smoothing methods, or by use of a Black-Clawson air knife system, in order to produce the particular coated finish required. All rolls are reversible and their variable speed requirements are controlled by variable speed A.C.N.S. equipment. Quick-acting pneumatically-operated equipment allows hand feeding, and "colour-off" conditions

Fully automatic coating preparation plant. The control cabinet contains a graphic panel which continuously records the condition of the mixes



Automatic high-speed coating machine installed by Brookgate Industries, Ltd. to make "Aerocote" art paper; both sides of the paper are matched during a single operation.

to be achieved quickly. Keith Blackman multi-stage air compressors supply filtered air to the air knives.

After being coated to a carefully controlled weight, the paper is assisted on to a conveyor, by a vacuum draw roll, which carries the sheet through a straight-path 100ft drying tunnel, after which it is further dried and conditioned in two cylinder sections. Both sections have 5ft diameter cylinders carried on hydraulic-release taper roller bearings housed in the specially designed open framing, and are driven through totally enclosed gearing. The cylinders are polished and fitted with pneumatic oscillating "doctors" to avoid dust and fluff. The lower cylinders are clothed in felt, with a special Belvit guide.

After drying and conditioning, an overdamping unit controls the added surface-moisture giving optimum supercalendering conditions. The coated web is then reeled on a specially designed automatic winder, which provides for surface and/or centre winding, together with reel removal without speed or tension variation. Sheet tensions of 2 lb per inch are easily obtained, giving a fairly hard reel of 50in diameter, suitable for supercalendering without re-reeling. The tension controlled drives are speed matched electronically with the machine sectional drive.

The various operations and actuations are carried out by Lang Pneumatic servo-mechanisms, in conjunction with automatic controls.

Sectional Machine Drive

The sectional machine drive comprises special d.c. "Velonic" speed control equipment, engineered and manufactured jointly by Printing and Paper Drives, Ltd., and Laurence Scott and Electromotors, Ltd.

The various sections are driven by d.c. electric motors direct-coupled to speed-reducing gearboxes. Ward-Leonard controls are used for the eight d.c. motors. The generators, boosters and exciters are accommodated on three motor-generator sets. The draw-on electronic control, between the different motors in each section, is by variation of booster output, each motor being supplied via a positive/negative booster. All motors are fitted with individual tacho-alternators whose rectified d.c. output voltage is compared with a master reference voltage in a summation circuit, any difference being amplified: the magnitude and polarity of this voltage determines the magnitude and polarity of the excitation of the split-field exciter and hence of the section generator.

The summation circuit error thus represents the difference between actual and desired speed of the sectional motor. The perpetual hunt is measured stroboscopically and is represented by a 48 per cent motor spindle deflection at maximum machine acceleration.

Actuation of draw control causes a change in the voltage needed from the sectional tacho-alternator to achieve balance in the summation circuit, and thus gives a different speed. A speed trim of ±15 per cent is available between each section. Slack take-up is available between sections: it is effected by introducing a temporary increase in voltage into the summation circuit.

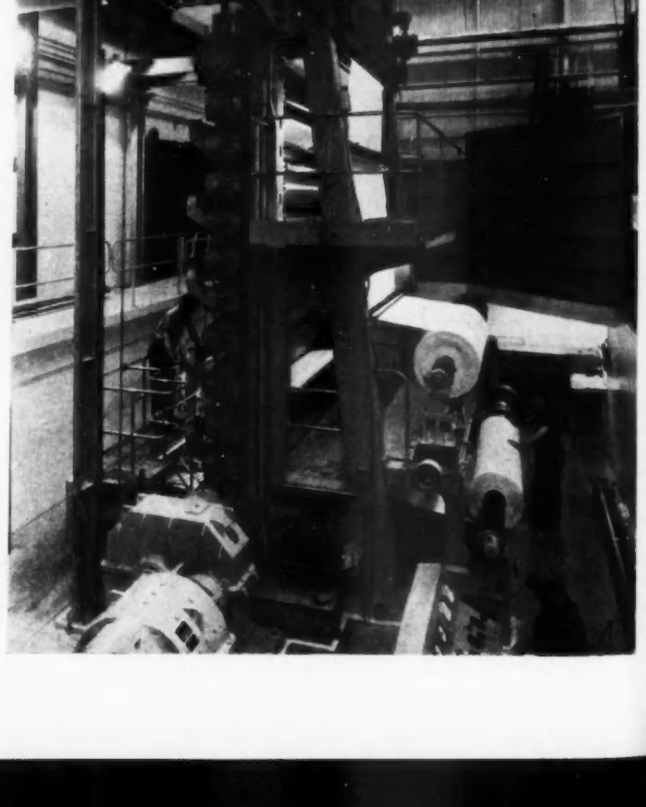
To obtain synchronisation all sections are "matched" during acceleration, to the one with the largest electro-mechanical time constant, by an adjustable time-lag in each of the individual summation circuits. For ease of control, both coarse and fine variable resistance are available. Speed indicators are installed for each section.

The basic controls provided are:

1. Inch, crawl, run and stop, and emergency-stop of all electronically speed controlled motors, in synchronism. It is possible to bring the machine to "rest" and restart without breakage of the paper-web.
2. Adjustable preset running speed, which may be adjusted during run.
3. Speed reduction buttons and individual draw controls as well as slack take-up to each section.
4. Static and running rewind tension control, including taper tension if required.
5. Dynamic braking available during automatic operation of unwind and rewind sections.
6. Individual isolation of all sections and all normal electrical safety and testing requirements.

Supercalender

The required high surface finish is produced by a twelve-bowl supercalender. All bowls are fitted with hydraulic-release taper-roller bearings, and are carried in quick-release housings. Continuous lubrication is by metered supply via a Wakefield lubricator. Roll loading is applied by a combined pneumatic/compound arrangement, having independent pressure control. The reel



The high surface finish required for the "Aerocote" art paper produced by the new coating machine is imparted by a twelve-bowl supercalender. The machine is served by an electric lift platform

unwind equipment is electrically traversed and is able to accept reels of coated paper from any machine. The rewind caters for web tensions of up to 3 lb per linear inch. An electric lift serves the supercalender platform. Safety is ensured by automatic "fail-safe" devices.

The coating machine was designed and largely built within the Reed Paper Group. We learn that the whole plant was in operation within twenty months of the decision to go ahead with the project.

CONTRACTORS

The main contractors and suppliers of equipment were as follows:

Alton and Co., Ltd., steam pipes; Arnolds (Branbridges), Ltd., aluminium hood, stainless steel handrails, platforms; Ashworth Ross and Co., Ltd., weighing machines; Audley Engineering Company, Ltd., special valves; Bells Asbestos Engineering Company, steam valves; Bentley and Jackson, Ltd., drying cylinder sections, felt parts; Black-Clawson International, Ltd., air knives; Brightside Heating and Engineering Company, Ltd., machine steam piping; British Vacuum Cleaner and Engineering Company, Ltd., air conveying systems for clay and adhesives; Coppas International, installation and start-up of instrumentation equipment; R. Corben and Son, Ltd., building contractors; D.S.T. Engineering Company, oscillating cylinder doctors; G. Durrant and Sons, Ltd., free running camber rolls; Elliott Brothers (London), Ltd., piping for instrumentation; W. T. Glover and Co., Ltd., electric cables; G. N. Haden and Sons, Ltd., Water heaters and heat exchangers; Harland Engineering Company, Ltd., coating pumps; Hopkinsons, Ltd., steam valves; Hunt and Moscrop, Ltd., supercalender and damping machine; Hydraulic Machinery Drives, Ltd., supercalender rewind; Lang Pneumatic, Ltd., servo-mechanisms on machine; Mono Pumps, Ltd., chemical pumping; Paterson Hughes Engineering Company, Ltd., clay roller conveyor system; Printing and Paper Drives, Ltd., machine supercalendar drive and control equipment; Renold Marsh (Heating and Ventilation), Ltd., motor generator cooling system; Saunders Valve Company, Ltd., special valves; Sheldons Engineering Works, Ltd. (Converted Products Division, Reed Paper Group), Coating heads, unwind, flying splice and rewind mechanism, air dryer, supporting structure, and specialised engineering; Spooner Dryer and Engineering Company, Ltd., air drying tunnel; Lightning Mixers, Ltd., equipment in preparation plant, stainless steel vessels and agitators; Taylor Controls, Ltd., automatic control equipment; Valvair, Ltd., solenoid-operated air valves.

British Standards Institution

No. 487 : 1960. FUSION-WELDED STEEL AIR RECEIVERS. PART 1: FOR PRESSURES NOT EXCEEDING 500 LB/SQ IN. Price 8s. 6d.

No. 1099 : 1960. SMALL FUSION-WELDED STEEL AIR RECEIVERS. Price 6s.

No. 3256 : 1960. SMALL FUSION-WELDED AIR RESERVOIRS FOR ROAD AND RAILWAY VEHICLES. Price 6s.

Of these standards B.S.3256 is new and the others are revises (B.S.487 : Part 1, and B.S. 1099). Earlier editions of the two revised standards did not apply to air receivers for use on the railways, but this restriction has now been removed. Additionally, at the request of user bodies, the new standard (B.S. 3256) has been prepared specifically to deal with small air reservoirs for road and rail vehicles. One outcome of the extensive revision of B.S.487 and B.S. 1099 is that thinner scantlings are now permitted for receivers constructed of material complying with B.S.1633 (steel for land boilers, receivers and other pressure vessels). All the pressure vessels dealt with in these three publications are classified according to the material and type of construction used and to whether they are heat-treated after construction. The text of each publication is amplified by many line diagrams.

PREPARED AND NATURAL TRACING PAPER

No. 1340 : 1960. Price 4s. 6d. This new standard provides methods of assessing quality by the use of standard methods of test for important characteristics. The standard relates to these types of paper in the form of rolls, reels, and cut sheets. Detailed test procedures are specified in respect of: ultra-violet light transmission; total light transmission; ghost marking; tearing strength; and ageing. These are preceded by concise instructions for conditioning the paper that is to be subjected to test. All the test procedures have been worked out with the collaboration of the British Paper and Board Manufacturers' Association. Sizes (with tolerance) are specified in respect of rolls and reels. The sizes of cut sheets is a subject under consideration by one of B.S.I's committees of experts; when a standard on drawing sheet sizes is published, B.S. 1340 will be amended to align with it. In a foreword to the standard it is pointed out that it may be possible to establish, in a future revision of the standard, values for the papers' characteristics.

Measurement of Exhaust Smoke Density

At a meeting of the Institute of Road Transport Engineers in London yesterday, Mr. J. D. Savage, A.M.I.R.T.E., A.M.I.Agr.E., delivered a paper on "Measurement of Exhaust Smoke Density from Diesel Engined Vehicles." We reproduce the greater part of the paper below.*

RESEARCH engineers and designers investigating diesel engine combustion problems have taken a keen interest in the behaviour of exhaust smoke since the diesel engine's earliest days. Smoke density has in fact become one of the most important criteria in determining the rated output of modern diesel engines; the maximum output being the maximum smoke-free output, or the smoke-limited power. Visual assessments of smoke density are now classified by the well-known descriptions "just visible" (JV), "visible" (V), "black" (B) and "very black" (VB). Useful as smoke density is, as a guide to the quality of combustion, its evaluation has proved difficult. Seen by the human eye, smoke is nebulous and changeable. Its appearance varies according to the nature of the background, it usually refuses to remain constant long enough for two observers to agree upon its density and it is, of course, completely invisible in the dark.

Consequently, efforts accurately to measure diesel exhaust smoke density have been extensive and a number of instruments have emerged to assist in the development work that has led to the acceptance of the diesel engine as a versatile power unit. Now, with the diesel engine's widespread use, especially for road vehicles, attention has been directed to the black exhaust smoke sometimes emitted by diesel engines on the road.

The problem of accurately assessing the density of the smoke from a moving vehicle is even more difficult and this has encouraged attempts to make use of the instruments originally developed as tools for combustion research and engine development.

THE DEVELOPMENT OF SMOKE-METERS

For fundamental investigations or practical development work on internal combustion engines, the engine test bed method is well established. In the earliest days, the engine dynamometer consisted of a simple rope brake and early smoke measuring devices employed a filter paper through which a known quantity of exhaust gas was drawn. The density of the smoke stain on the filter paper was assessed by visual comparison against standard density charts.

The rope brake was soon succeeded first by the hydraulic, and later by the electrical dynamometer, which lend themselves to simple remote control. The modern test bed can therefore be placed in a cubicle, usually soundproofed, with the operator or tester sitting comfortably at a control console outside. Instruments are usually continuous-reading, and of the distant-reading type, with dials and gauges grouped at the console for ease of observation. For smoke-meters to be conveniently applicable to these test beds, they too should be capable of giving continuous direct readings, and be adaptable to remote reading if desired. This trend, together with the fundamental advantage of an instrument capable of detecting transient smoke density, led to the interest in the use of the light absorption meter, originally developed for dust measurement. One of the earliest, if not the first, to be applied to exhaust smoke measurement was described by P. H. Schweitzer in 1938.

The principle was embodied in the American C.R.C. Smoke-meter, and marketed by the Photovolt Corporation. The Swedish company of VOLVO have also employed this principle with some success.

In the United Kingdom the arrangement was redesigned by The British Petroleum Research Centre for research investigations with the provision of a second tube through which air is passed for zero calibration. The air also served to keep the light source and photo-electric cell free from soot deposits. This dual-tube smoke-meter has been further developed and is marketed for general use by Leslie Hartridge, Ltd., Buckingham, as the Hartridge BP Smoke-meter.

FEATURES OF LIGHT ABSORPTION SMOKE-METERS

With the various types of light absorption smoke-meters, a probe placed in the exhaust system feeds a continuous sample of exhaust gas by the smoke-meter. If an air fan is incorporated in the meter, the pressure of the smoke sample must be greater than the pressure of the incoming air, or the air infiltrates into the smoke tube and gives a low smoke density reading.

The temperature of the gas reaching the smoke-meter must not be too high, or the photo-electric cell suffers, yet the gases must not be excessively chilled or condensation may occur. This is a problem that will be dealt with later. It is, nevertheless, usually possible to determine satisfactory test bed installation conditions for any particular programme, and thus be able to take advantage of the instantaneous direct-reading and continuous sampling features of the photo-electric light absorption smoke-meter.

With these instruments, variations in smoke density due to changes in operating conditions can easily be observed, and changes due to engine deterioration can also be noted.

Despite the extensive use of these smoke-meters for test bed investigations they can only reliably be used to determine relative smoke density. The theoretical expression for the light absorbed in the tube includes a constant which applies to a given set of conditions dependent on the wavelengths of the light source, length of the smoke tube, the particle size distribution, the surface properties of the particles and the manner in which they orient themselves in the tube. As the precise determination of these factors is not usually possible, readings cannot be corrected to give absolute values for various conditions. Correlation of results from two or more different types of instrument is difficult for similar reasons. However,

* Technical Services, Market Department, British Petroleum Company, Ltd.

experience has shown that the light absorption smoke-meter gives results of acceptable accuracy especially in the middle of the smoke-meter scale where the sensitivity is approximately linear.

Features of Filter Paper Disc Techniques

Filter paper methods have survived the competition from light absorption instruments. The Saurer Company have developed an improved version of the original bottle type, and The National Institute of Agricultural Engineering have developed a variation that is regularly used for practical smoke density evaluations. Robert Bosch of Stuttgart have recently marketed a kit that comprises a mechanical sampling pump and a photo-electric evaluation unit for measuring the density of the smoke stain on the filter paper disc.

These units are not suitable for measuring transient conditions, and they do not sample continuously or give direct instantaneous readings. For steady running conditions they are reliable and effective for recording relative densities but, like the light absorption smoke-meter, suffer to some extent with reduced sensitivity at high smoke density, due to the greater probability of particles overlapping and layering. The results from different filter disc systems cannot be correlated if the sample volumes, flow rates, filter areas, &c., are different, although results from different instruments can be expressed in terms of unit flow rates, volumes and filter areas, for purposes of comparison.

Correlation of Light Absorption Smoke-meter Readings and Filter Paper Results

Filter paper results can only be correlated with the results from light absorption type meters for a given set of conditions. Apart from the fundamental differences previously mentioned correlation is also hampered by the fact that filter techniques usually detect black smoke, whilst the light absorption type is sensitive to black and blue smoke, and condensation in the form of water vapour.

Influence of Blue Smoke.—Blue smoke particles, which are probably smaller than particles of black smoke, pass through some filter papers undetected, but in the light absorption smoke-meter they are recorded as black smoke.

Blue smoke is of interest, because it gives an indication of engine condition, but unfortunately the light absorption meter cannot differentiate between blue and black smoke. It would therefore be beneficial if a refinement in the form of a light filter was eventually developed to enable black and blue smoke to be identified and separately evaluated.

Influence of Condensation.—Visible water vapour is not usually evaluated because it normally only occurs when the engine is cold. Condensate usually invalidates filter type tests by soaking the filter paper. In the light absorption meter the light beam will be interrupted, reflected and deflected to give a reading that can be mistaken as an indication of the degree of blackness. If the exhaust smoke is cooled at a rate which causes the water vapour in the exhaust to condense into droplets in the smoke tube, spurious results will be obtained due to the influence of vapour that does not even exist, in visible form, in the main exhaust stream. If the problems of condensation cannot be overcome by adjustment of the sampling technique (position of probe, &c.) the exhaust gases must be completely cooled and dehydrated before they reach the smoke tube, or alternatively they must be maintained at temperature until they have passed through the tube.

Other Smoke Measuring Procedures

In the foregoing sections the two types of smoke measuring techniques in most popular use, viz. the light absorption smoke-meter and the filter paper disc method have been considered and compared. Before considering the application of these techniques to the measurement of exhaust smoke from vehicles there are certain other procedures worthy of brief consideration.

Moving Paper Strip Method.—The Von Brand instrument originally developed for chimney-stack work and marketed by E. K. Von Brand N.Y., U.S.A., employs a moving filter paper strip. By varying the speed of the tape and the size of the smoke nozzle, extreme sensitivity is obtained over a narrow range. The Von Brand instrument has the advantage of being continuous reading, and capable of observing transient conditions provided that wide variations in exhaust smoke density are not encountered in a given test run. The smoke stains on the paper strip can be evaluated with a photo-electric unit. This instrument is attractive for the critical examination of exhaust smoke density under laboratory conditions.

Photographic methods. — Photographic methods have been tried without success. It appears that the " eye " of the camera has as much difficulty as the human eye in coping with the vagaries of exhaust smoke appearance.

The " Fumograph."—Professor Malschaert of Ghent University recently described a technique developed by Mr. P. Siex, Engineering Director of the Brussels Omnibus Organisation. It is called the " Fumograph." A sheet of suitable paper is placed in the gas stream 50cm from the exhaust outlet to produce a stain which can be evaluated by light reflection methods. This technique has the merit of being simple in the extreme, and it provides a permanent record. It is not continuous, and like the filter disc technique, cannot be used to observe transient conditions.

MEASUREMENT OF SMOKE DENSITY FROM VEHICLES

At least a quarter of a century has been devoted to the problems of measuring the density of exhaust smoke from diesel engines during test bed investigations and the problems have not all been solved. Despite their limitations, we are on the threshold of a completely new application of smoke-meters ; the measurement of smoke density from diesel engined vehicles.

The three principal factors that have promoted interest in smoke-meters for vehicle work are :

(1) Operators' moral obligations to keep exhaust smoke density to an acceptable level.

(2) Possibility of tighter legislation in certain countries to enforce regulations about the emission of smoke from vehicles.

(3) The diagnosis of engine troubles and monitoring engine deterioration.

The use of smoke-meters for these tasks brings a new series of problems that are superimposed on the fundamental difficulties.

Requirements of Test Procedure.—When an engine is in good mechanical condition the maximum smoke level will occur at a particular condition, e.g. maximum torque, maximum power, maximum speed. The condition that produces the maximum smoke level can be determined for any particular engine and is used by the engine manufacturer when setting the maximum smoke-free output of the engine on the test bed.

On-the-road determinations of smoke density can also be conducted at the condition known to produce the most smoke when the engine is in good condition but if the engine has deteriorated in service the exhaust density should be measured over the whole speed range or a false impression may be gained. This is why a continuous sampling system is so desirable. When sampling from vehicles in a mixed fleet the condition that produces the most smoke may not be known for every vehicle.

For long-term test bed investigations it is accepted that it is permissible to take the exhaust sample from a tapping in the exhaust manifold or exhaust pipe, but if the exhaust-smoke density from a number of different vehicles is to be evaluated easily and quickly, only tail-pipe sampling is acceptable. This has the additional attribute of measuring the smoke density at the point at which it appears.

Tedious complex installations and test procedures can be relied upon to breed undesirable prejudices among drivers and mechanics. The installation of the equipment must therefore be quick and simple, and testing procedures must be equally rapid and straightforward. Fortunately tail-pipe sampling methods now in use are quick and simple to employ. Loading and unloading the filter discs may put this method slightly out of favour with the operators, but this disadvantage is probably offset by the more tangible nature of the results obtained with the filter paper method. Both the filter paper techniques and the light absorption smoke-meters have been widely applied to vehicle tests, and can be installed and used within a few minutes.

Although it may not always be necessary to conduct tests under normal driving conditions, it should be possible to do so in cases of doubt or dispute and for correlating test procedure results with results obtained under normal driving conditions.

Summarising, the requirements of a test technique for the evaluation of vehicles exhaust smoke density are :

(*a*) Continuous, direct, instantaneous readings ; (*b*) Tail-pipe sampling ; (*c*) Speedy installation and procedure ; (*d*) Suitable for use with vehicle operating normally.

Whereas the light absorption smoke-meters appear to satisfy these requirements completely, the filter disc method does not because it is not of the continuous sampling type. It may be wise, however, not to reject it, because for vehicle work it has two inherent advantages over the light absorption unit :

(1) In that it automatically provides permanent, tangible record of the smoke density, and

(2) The evaluation of the samples can be carried out at leisure after the test on the vehicle has been completed.

A permanent record, for evaluation after the actual test, can also be obtained with a light absorption smoke-meter by using a recording instrument in place of the dial type micro-ammeters normally used but this equipment is rather too cumbersome to install for anything other than a long term investigation. The record thus obtained, although permanent, is less tangible than the smoke stain on the filter paper discs.

Comparison of Methods.—Light absorption instruments are more versatile than the filter

paper units, especially for the diagnosis of engine shortcomings, and may therefore appeal to the operator. Authorities introducing a standard test for legislative purposes may be attracted to the filter disc technique because of the permanent tangible nature of the result, which might be more readily understood by the layman.

Both techniques can be used for determining smoke density over a range of conditions or at any chosen operating condition, but the determination of maximum smoke density is the task for which they are most frequently used.

For determination of maximum smoke density by the filter disc method, the sample must be taken at the condition which is known to produce the maximum smoke density and it has been demonstrated that this condition varies from engine to engine. It may also vary in service due to engine deterioration. With the continuous sampling technique of the light absorption smoke-meter, the engine can be operated under conditions which are varied until the maximum smoke reading is indicated. With both techniques the engine must be operated in a way that ensures simulation of full-load performance and there are two basic ways in which this can be done.

Possible Test Methods

Possible test methods may be broadly classified as: Mobile methods; Stationary methods.

Mobile Methods.—(1) Accelerating the vehicle until the maximum (governed) speed is reached. (Maximum accelerator pedal deflection must be used throughout.)

(2) Driving the vehicle up a gradient with full "throttle."

(3) Driving the vehicle at full "throttle" and applying the hand brake until the "stall" condition is approached.

For establishments with their private test circuits, any of the foregoing procedures can be adopted, but (2) and (3) have advantages over (1) because the vehicle can more easily be maintained at the full-load condition for several seconds. This is particularly necessary when the filter paper technique is employed.

The three mobile tests can, of course, be conducted on public roads, but there are good and obvious reasons why this should not be done. When highway testing is not acceptable, the driven wheels of the test vehicles could be placed on rollers, and the conditions equivalent to those specified in mobile methods (1) and (3) could be obtained with the vehicle immobile.

Whilst this is a reasonable approach, the provision of rollers may only be considered justified if the simpler procedure of testing by the Stationary or Engine Acceleration Method is not acceptable.

Stationary Method (*Engine Acceleration Method*).—In this method the clutch is disengaged throughout the test, and the vehicle remains stationary while the engine is accelerated. The accelerator pedal is instantaneously depressed to its maximum displacement and held there while the engine speed rises to its maximum.

This method can only be used when a continuous sampling instrument is employed, because the engine operating conditions are changing continuously throughout the test. With a continuous sampling instrument the variations in the density of the exhaust smoke can be observed throughout the test and the maximum reading occurring can be noted. It is also possible to see whether the peak occurs on the bottom end of the speed range, midway, or at maximum speed. Compared against the background of the exhaust characteristics for the engine when in good mechanical condition this type of information is most useful for diagnosing engine deterioration.

One drawback with this procedure is the way in which residual soot in the exhaust system of some vehicles is displaced to result in an unreasonably high density reading. This would not matter if all the residual soot was expelled in one test as a preliminary scouring run could precede each authentic test. Unfortunately the dispersion of residual soot can take several accelerations. Also, it is vital to conduct this test with a fully warmed-up engine or false readings may be obtained. With the engine warmed up, the test should be repeated until consistent results are obtained.

Correlation of Results from Various Test Methods

From Table I it can be seen that very similar results are obtained with the four different methods of test in the cases of engines 1 and 2. With engines 3 and 4 the Stationary Method under-estimates the density obtained with the Mobile Methods.

Table I

Comparison of Results by Rapid Methods (Typical Figures)

	Large direct injection engines (over 8-litre) Light absorbed—per cent					
	Engine No. 1			Engine No. 2		
Reading No. ...	1	2	3	1	2	3
Stationary test ...	93	95	98	46	44	48
Acceleration test ...	94	94	93	47	48	50
Braking test	96	98	96	58	54	56
Hill Climb test ...	86	92	92	—	—	—

	Small indirect injection engines (under 2·5 litre) light absorbed—per cent					
	Engine No. 3			Engine No. 4		
Reading No.... ...	2	2	3	1	2	3
Stationary test ...	36	38	36	48	48	51
Acceleration test ...	60	57	60	80	85	85
Braking test	62	60	64	85	90	85
Hill Climb test ...	64	66	68	90	95	90

Table II

	Comparison of stationary method results and full load steady-speed results on a variety of engines Light absorbed—per cent					
Engine No.	5	6	7	8	9	10
Stationary test ...	38	55	30	62	33	50
Full load density...	45	66	35	70	40	60

The lack of correlation with these two engines was, at the time, attributed to the condensation of water vapour into droplets in the smoke tubes, due to the small volume and low temperature of the smoke being sampled. When these results were obtained no facilities were available for overcoming these problems and the results serve to illustrate how important it is to prevent condensation from influencing results. This has now been achieved with a modified instrument.

Table II shows a comparison of results obtained on the test bed with six different engines. The Stationary Method again underestimates the density as measured under steady full-load conditions.

It can be said on the basis of results in Tables I and II and many other tests that have been conducted by the author and other investigators, that the Stationary Method has a tendency to underestimate the steady full-load maximum smoke density by 0 per cent to 20 per cent according to the type of engine and exhaust system under test. For the reliable evaluation of smoke density by the Stationary Method it is obvious that preliminary investigations must be conducted for a given vehicle type to determine its particular correlation pattern.

Results obtained with the Stationary Method should be viewed with suspicion unless supporting evidence of correlation with full load Mobile tests are presented for the particular vehicle type under consideration.

Smoke-meters for Diagnosing Engine Condition

For diagnosing engine faults with the aid of a smoke-meter an historical record is probably the most useful approach. If a weekly or monthly check is made on smoke density from the time the vehicle is new, or the engine reconditioned, a "life" plot can be produced for each vehicle. This method soon reveals progressive trends and it highlights sudden changes. As with fuel and oil consumption figures, more value can be obtained from this type of record than by comparing results from two or more vehicles. The risk of spurious results remaining undetected due to condensation, sampling technique, &c., is reduced because these problems can be fully investigated and overcome before regular testing commences.

Comparison of results from a particular vehicle against the general mean of results from a number of vehicles is also useful. This is virtually the procedure adopted by authorities and will be discussed later.

The techniques described under the heading "Possible Test Methods" can be effectively used for diagnosing engine troubles, including: Stuck injector needles; blocked nozzle holes; over-fuelling; incorrect timing; dirty air cleaners.

The various troubles give their particular smoke signals which can be readily recognised with a little experience. To assist with diagnostic work, additional instrumentation is valuable.

The use of smoke-meters for diagnosing engine condition is a study in itself that might at a later date form the subject of a sequel to this paper.

Smoke-meters for Official Use

Whether or not the interest in diesel engine exhaust smoke emission is justified on the basis of road safety, public health or other considerations, is not a matter for this paper. The fact remains that with the widespread and growing use of diesel engines for road transport, authorities charged with the task of controlling the condition of vehicle exhaust smoke may find it increasingly difficult to rely entirely upon visual assessment and regulations that do not define acceptable and unacceptable levels of exhaust smoke density. In Belgium and Western Germany, for example, official smoke checks are already being conducted on an experimental basis.

Visual assessments of smoke density are still effectively employed by the London Transport Executive, who are generally considered to achieve satisfactory control over the emission of exhaust smoke from their buses. However, L.T.E's Fuel Economy Officers can err on the strict side without causing any hardship or serious contention. If official inspectors were to overestimate the density of the smoke from a vehicle because of the prevailing light and atmospheric conditions or the influence of the background, the operator of the vehicle might be unjustly penalised.

The introduction of a standard technique for the official measurement of smoke density could therefore be considered to offer operators a safeguard. But, to be accepted, the technique employed would have to be

reliable, consistent, unbiased and foolproof. It should be impossible to fake or unintentionally misrepresent the results.

From previous considerations of the light absorption smoke-meter and filter paper techniques, it has been seen that there are limitations with both types. It remains to be considered whether these limitations could preclude their use for the official measurement of smoke density, the results of which might be used for judicial purposes.

Filter Paper Technique for Official Use.—As with this system smoke checks can only be obtained under steady running conditions, several samples should be taken over the range of operating conditions, and the evaluation must be based on the highest density recorded. This procedure is time-consuming, inconvenient to both operator and tester and, as the test would almost certainly have to be conducted on the open road, it might become a menace to other road users. Also, it is unlikely that any authorities would be prepared to undertake the responsibility of testing on the road, as in most countries insurance policies would be invalidated and existing regulations would be infringed. The provision of special test tracks or roller installations are possibilities that could provide a solution for the authorities, but only at considerable expense. Operators anxious to avoid infringing smoke regulations might find it difficult to conduct their own test under similar conditions to the authorities, unless private roads or roller rigs were available to them.

For official use these drawbacks appear to outweigh the main advantage of the filter paper method ; namely, a simply obtained, permanent and tangible record of the density.

If this system is ever adopted by any official body, it is likely that a single test would be made. The one sample would be passed through the filter paper with the vehicle running in direct drive at (say) 40 per cent of the maximum speed, a condition obtained by application of the hand brake while the accelerator pedal is fully depressed (i.e. Mobile Method No. (3)). With this procedure it is virtually impossible to produce abnormally excessive smoke. Any attempt by the driver to falsify the results by deliberately keeping the accelerator pedal off the stop, would be to the advantage of the operator rather than the inspector.

Official Use of Light Absorption Type Smoke-meter.—If the light absorption smoke-meters are ever adopted by official bodies for evaluating exhaust smoke density, the factor most likely to be responsible for their adoption rather than other systems, is the attraction of a very simple rapid test conducted while the vehicle is stationary.

If, in the Stationary Method the driver does not fully depress the accelerator pedal when the residual soot is being expelled from the system, an unreasonably high result may be obtained when the actual smoke reading is being recorded. Drivers must therefore be encouraged to depress the pedal fully throughout the entire test procedure, and assessments must, to be reliable and fair, be based on several successive engine accelerations.

The Stationary Method has been shown to give an indication of maximum smoke density that may tend to underestimate on-the-road evaluations, but can be correlated in the case of any given type of vehicle. As obtaining the correlation pattern for every vehicle likely to be tested by the Stationary Method would defeat the object of this type of test, especially for official purposes, wide limits would have to be set to accommodate differences from vehicle to vehicle. The density range would have to be divided into perhaps three sub-divisions rather than the 100 units currently employed. The three sub-divisions might be labelled " Invisible," " Visible but Acceptable," " Unacceptable."

Border-line cases would have to be given the benefit of the doubt, and some offenders would escape—as always—but in general the really bad smokers would be identified, and this would be the prime purpose of any official control of vehicle smoke density by instrumentation.

The smoke-meter would have to be positioned so that the driver could observe the readings as proof that the correct result had been recorded.

The possibilities of the test method have been demonstrated in Belgium where, out of 19,214 vehicles tested, 2030 (i.e. 10·6 per cent) gave readings in the " Unacceptable " range, as assessed by the Stationary Method. All of the vehicles in this group that were repaired or adjusted following the first test (i.e. 1168) gave a reading better than the " Unacceptable " level when re-tested.

Smoke Density Limits

For private fleet use, especially fleets of rather similar vehicles, setting limits for the smoke density presents no real problems ; it is a matter for the individual operator's choice. For official use, or any application where many types of vehicle are involved and where different types of smoke-meter may be used, the specification of general limits, except in the broadest terms, may lead to difficulties.

If the values indicated by a particular type of smoke-meter are fully accepted as giving reliable readings under prescribed conditions, there is still a natural human desire to relate the instrument's interpretation of the smoke's condition to its observed appearance and we are faced with agreeing standards on a visual basis.

Nevertheless the smoke-meters are not invalidated ; it does not mean that individual visual assessments might as well be made in the first case thus dispensing with the smoke-meters and all their problems. Visual assessments for determining standard densities are made under standard conditions by a number of people. At the same time, smoke-meter readings are obtained and recorded against the observer's interpretation.

The simple case is the " just visible " condition. If a number of observers agreed that the exhaust smoke density from a particular engine running under prescribed condition was " just visible " at smoke-meter readings of between 27 per cent light absorbed and 39 per cent light absorbed, the average figure of 33 per cent could be quoted as a reasonable approximation of the " just visible " condition for general purposes.

Effect of Engine Size.—The diameter of the exhaust pipe, its shape and position under the vehicle, and the direction in which it points are all factors that influence the visual appearance of the smoke but do not normally affect smoke-meter readings. The various effects of these factors on visual observations are far too numerous to evaluate.

Engine size on the other hand, has an effect on the visual observations that can be readily related to the volume of exhaust smoke—in other words, a lot of light smoke looks, to most people, as bad as a small volume of very dark smoke. The Robert Bosch Company have co-operated with the Technical Inspection Authorities of Federal Germany in an attempt to eliminate this factor. A 250 b.h.p. engine is considered to exceed the limiting value if a Bosch smoke-meter reading of 5·0 is obtained, whereas a 50 b.h.p. engine can emit smoke giving a meter reading of 6·5 before it is considered to be beyond the limiting value. Brake horsepower has been used as a convenient indication of engine size, although the relationship is really associated with engine capacity (swept volume).

When considering the results of the Bosch apparatus and the Hartridge BP Smoke-meter, correlation as was to be expected, has been found to vary from vehicle to vehicle. Therefore, it is not possible to relate the Bosch investigation to results obtained with light absorption meters.

As a general guide, the following scale has been adopted by BP for the Hartridge BP instrument and engines of 5·0 litres or more.

Visual Smoke-meter	Just Visible Percentage	Visible Percentage	Black Percentage	Very Black Percentage
	30	50	70	90

A British bus fleet operator has considered the possibility of setting a limit of 50 per cent light absorbed. Any bus giving a reading below 50 per cent value would be allowed to continue in operation, but if a density of more than 50 per cent is shown, the bus would be inspected, and receive attention. This system has not been adopted, visual assessments are still employed.

In Belgium the official Inspection Stations have set two-stage limits with the Stationary Method. Vehicles giving a reading of less than 45 per cent are cleared ; between 45 per cent and 75 per cent, the owner is advised to inspect and correct : over 75 per cent, the owner is obliged to rectify the cause of the excessive smoke, and re-submit the vehicle for a further check after the shortcoming has been rectified. These limits are entirely experimental and may well be modified in the light of results obtained from the large scale trial that is now in progress.

This section must end with a renewed warning that general correlation of results from different types of smoke-meters is not possible unless wide limits are tolerated. For official purposes, where a " pass " or " fail " system is required, the three sub-divisions of the scale previously mentioned might suffice, i.e. " Invisible," " Visible but Acceptable " and " Unacceptable." This might lead to a limit of up to two-thirds light absorbed being accepted with any instrument together with a correction factor for engine size. Any new smoke-meters would then be produced so that the two-thirds figure could be roughly related to the observed density that is considered to be objectionable or unacceptable as determined by standard visual assessments.

As reference has been made to investigations in various countries, it is desirable to mention that whilst fairly wide interest is being shown in exhaust fumes in the U.S.A., most of the current work is concerned with exhaust smoke odour and eye irritation produced by the kerosene-type fuel used for city bus operation rather than the density aspect discussed in this paper.

CONCLUSIONS

Existing smoke-meters may not be considered ideal for measuring the density of exhaust smoke emitted by all types of diesel engined vehicle, but they can be satisfactorily utilised provided that certain limitations are accepted and certain precautions taken.

The limitations of existing instruments are related to :

(1) The difficulties of correlating results from different instruments.

(2) The smoke-meter's inability to give readings corrected for engine size, or volume of exhaust gas.

(3) The need to conduct the test procedure with extreme care to avoid incorrect readings due to accumulated smoke, condensation, low sampling pressure, etc. (These limitations can mainly be attributed to the fact that the various systems in use employ sampling techniques which bring their own particular problems).

(4) The fact that they do not examine the full-flow characteristics of the exhaust gas as seen by the human eye.

In addition to improving the existing sampling systems to reduce these limitations, the future development of smoke-meters for vehicle work might take into consideration the possibility of a full flow photo-electric light-absorption meter. Reasonable correlation should be possible by employing the iris type shutter to correct the light absorption reading according to the size of the exhaust pipe or the capacity of the engine.

ACKNOWLEDGEMENTS

In addition to thanking the authors of the papers in the bibliography the author would like to thank his colleagues in The British Petroleum Company and the diesel engine industry, who have given valuable advice on the content of the paper. Appreciation is also expressed for permission to use the results obtained by the Fonds d'Etudes et de Recherches pour le Securité Routière, Belgium.

The author wishes to thank the Chairman and Directors of The British Petroleum Company for permission to present this paper.

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"The Detection of Fumes from Diesel Engines," Professor F. P. Malschaert, Brussels, September, 1960.

Early 0-6-0 Goods Locomotives

By A. J. RICHARDS

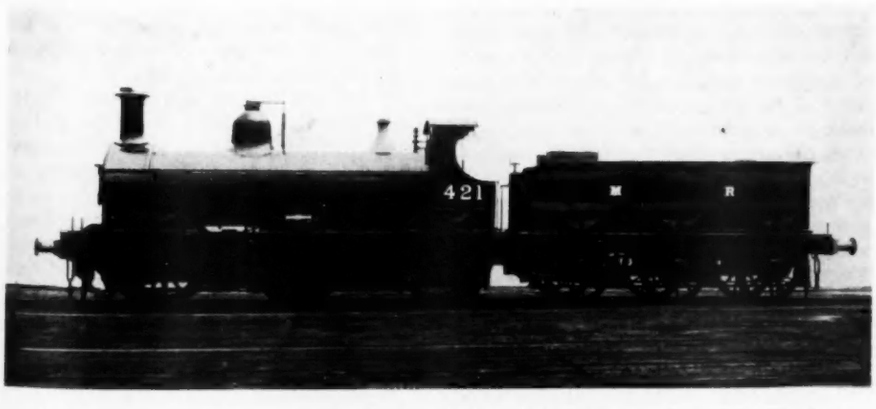
THE six-wheels coupled tender locomotive was always a popular design for goods and, in some cases, passenger duties in this country. The most numerous examples probably were found on the Midland and the London and North Western railways. The normal 0–6–0 British freight locomotive had inside cylinders and frames, with the trailing axle situated behind the firebox. The first engines of this arrangement and type for the 4ft 8½in gauge appeared in 1848. They were manufactured simultaneously by Kitson, Thompson and Hewitson, of Leeds, and B. Hick, of Bolton. The Kitson engines were of more up-to-date design and superior in workmanship to those built by Hick, which were provided with the old gab motion and, as far as can be traced, were the last main-line engines in this country to be so fitted. An interesting example of one of these Hick engines was described in THE ENGINEER for June 25, 1920.

The Kitson engines, built for the Midland Railway and the Leeds and Thirsk Railway simultaneously, had the following features: cylinders 17in diameter and 24in stroke; wheel diameter 4ft 9in; boiler, length barrel 11ft, diameter 3ft 8¼in, containing 162 tubes of 1⅞in diameter which provided a heating surface of 908 square feet, the total heating surface amounting to 1001 square feet. The locomotives had link motion and the engine wheelbase was 15ft 6in, equally divided. A distinguishing feature which they had in common with the 2–4–0 passenger engines built for the Leeds and Thirsk Railway in 1849 was that the main frame plates at the trailing end were bolted on to the outside of the frame plates, which extended from the front buffer plank to the firebox casing, they themselves thus forming a portion of the latter. The lower sections of the side water spaces were therefore bounded by the firebox copper plates inside and the outside frame plates, the stays being riveted over outside the latter. Angle irons formed the joint between the front and back plates of the casing and the frame plates, this arrangement providing a wide firebox, measuring 3ft 7⅞in inside with 3in water spaces. A somewhat slight drawback, however, was that no "breathing" was permissible.

The last batch of these engines built for the Midland Railway by Kitson came out in 1856 and ran for some ten years in their original condition. They later, however, came in for much attention from Matthew Kirtley who completely reconstructed them at Derby on orthodox lines, providing them with outside frames and new boilers, whilst R. M. Deeley later carried out several detail modifications towards the end of the engines' careers. Unfortunately, the writer has no particulars regarding the details of the engines in their reconstructed form other than the British Railways photograph (reproduced here) of No. 421.

This engine, later renumbered in the early "2300" series, was the last of the type to remain in service, being withdrawn in 1929. It was not cut up immediately, however, and the following year Sir Henry Fowler decided to preserve this last example as an engine of historical interest. Accordingly the locomotive was overhauled and repainted in the Midland goods black livery; the original number—421—was restored, whilst two small brass plates were made bearing the inscription "Kitson, Thompson and Hewitson, Makers, Leeds, 1856," these being affixed one to each of the driving wheel splashers. For a considerable time the engine was housed in the paint shop at Derby Works, but later the space occupied was needed for other purposes, and in 1934 Mr. W. A. Stanier finally decided to cut the engine up as at that time no other suitable place could be found for its preservation.

It is interesting to observe that the 0–6–0 type engine with *outside* frames and trailing axle behind the firebox first originated in 1834, this being Stephenson's engine for the Leicester and Swannington Railway. In 1847–48 there appeared a revival of this type, most of the new examples being built by E. B. Wilson and R. Stephenson and Co.



Midland Railway goods locomotive of 1856 after rebuilding by Kirtley and subsequent modifications by R. M. Deeley

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"THE WAYS OF WATER."—"The Ways of Water" is a new 16mm film describing the facilities and work of the Hydraulics Research Station; it is in colour with an explanatory soundtrack and runs for about twenty-eight minutes. The film is intended mainly for professional engineers, students and members of professional and scientific bodies in the field of hydraulic engineering and fluid mechanics. "The Ways of Water" is distributed by the Central Film Library of the Department of Scientific and Industrial Research.

HONEYCOMB PROCESSING DATA.—The first of a new series of data sheets has been issued by CIBA (A.R.L.), Ltd., on "Aeroweb" aluminium honeycomb core materials for lightweight structures. This sheet, known as Production Information Sheet No. 1, gives the maximum allowable pressures for bonding various types of "Aeroweb" core of NS3 material between skins. The new series supplements the existing Aeroweb Design Information Sheets which are available from the manufacturers, CIBA (A.R.L.), Ltd., Duxford, Cambridge, England.

SYMPOSIUM ON HYDRAULIC STRUCTURES.—A Symposium on "Analysis and Design of Hydraulic Structures" is to be held at the Indian Institute of Science, Bangalore, in October, 1961. The Institute states that research workers and designing engineers who wish to contribute papers may send abstracts to the professor of civil and hydraulic engineering before June 30, 1961, and the full text by August 31, 1961. Further particulars may be obtained from the professor of civil and hydraulic engineering, Indian Institute of Science, Bangalore 12, India.

TRIGGERING OF SILICON CONTROLLED RECTIFIERS.—Further improvements in the trigger characteristics of silicon controlled rectifiers are announced by the Electronic Apparatus Division of Associated Electrical Industries, Ltd. In September the maximum trigger current required to fire any rectifier was reduced from 350mA to 150mA; it has now been cut to only 100mA and the maximum voltage required is reduced to 3·75V (formerly 5V). The improvement will especially benefit users who wish to employ pulse triggering of controlled rectifiers.

LETTERS AND LITERATURE

Letters to the Editor

MILLIONS TO BE SAVED

SIR,—I suggest to Mr. Douglass that my confusion of thought, in so far as it exists, originated from Mr. Gordon England's reference to the "form of transport which gives users personal choice at all times." I said that I took this to refer to private cars. Mr. Douglass and Mr. Lloyd on the other hand both refer exclusively to the substitution of trains by motor buses, which would have no effect on freedom of choice. Is there no confusion of thought here ?

If the converted railways are used by both private cars and public service vehicles most drivers who now choose trains would probably still prefer public transport owing to parking problems.

If we are agreed to consider the straight issue of road versus rail public service vehicles for densely occupied routes, the advantages claimed for the former seem to be greater comfort and frequency. Mr. Douglass refers to draughty stations, broken journeys, noise, dirt and overcrowding. The draughtiness of stations is entirely unrelated to the type of rolling stock (in so far as buses would have stations at all), broken journeys and overcrowding relate to the frequency of service, and noise and dirt seem to refer to steam haulage, which is not in the future picture anyway.

The alternatives are electric railways and converted roads. Mr. Lloyd claims an advantage for forty-seater buses at seven minute intervals, but if that is what he wants it can be provided equally easily in the form of individual electric motor coaches—once a line is electrified the cost of additional frequency can almost be regarded as marginal. The advantage of the road seems to come down to the greater silence of rubber tyres—if the buses exceed the statutory length of road vehicles there is clearly no gain in flexibility and the users will still not have achieved this "form of transport which gives them personal choice at all times." As against these marginal advantages consider what would be lost for ever if this radical change were once made.

1. A safety and reliability of operation under all weather conditions which is, and is likely to remain, unequalled by any other form of transport. I know that inductive guidance of road vehicles is theoretically possible, but even if this were extended to include the dead-man's handle it would do no more than approach railway standards of safety at a fantastic cost. I presume Mr. Lloyd would not claim automatic cab signalling to be applicable to road vehicles. I believe it is the fact that on the G.W.R. there was no accident from 1890 to 1940.

2. Flexibility in the size of single units from 50 tons to 1000 tons under the control of two men, and much greater room and freedom for the individual traveller. As the ideal Mr. Lloyd speaks of giving bus travel "all the luxury of air travel first class." There are people who prefer the existing luxury of rail travel first class where in addition to roomy seats they can stretch their legs, or walk down the train to talk to a friend if they want.

3. The bulk application of power to transport afforded by electrification, as against a huge number of individual prime movers, and all the maintenance and replacement involved, not to mention the exhaust fumes. This means in the near future, home-produced atomic power and one indication of the longer term possibilities is the development of the longitudinal induction motor at Manchester University, as reported in the *Guardian* on February 2, which would eliminate all mechanism. A further possible development is completely automatic control—if we stick to rails. Incidentally, I assume that Mr. Lloyd is not advocating the conversion of the Underground. Mr. Douglass says that the only people who have not heard of the idea of railway conversion are the politicians. I suggest that engineers should first make up their minds about this engineering problem, and present as factual a report as possible to the laymen. My own view is that the development of road and rail should proceed side by side as rapidly as possible, uneconomic sections of railway being converted to roads as they become available. Would Mr. Lloyd not agree that the M1 is a better road than the converted L.M. main line, including Watford and Kilsby tunnels?

J. R. HARDING

Sutton Coldfield,
February 10, 1961.

SIR,—I should like to comment on the letters of Mr. J. R. Harding and Mr. J. V. Walker, January 17 and 29 respectively.

The reason for so many cars being parked at Southern Region stations is twofold. First, with the Government bent on a policy of regulations to solve the road traffic problem (instead of getting down to building motorways through the cities and car parks) it is quite impossible to park a car in London on a day basis. Secondly, vehicle progress on what must be the most antiquated road system of any country in the world claiming to have a high standard of living, is so slow and frustrating that some of us prefer to pay exorbitant fares and go by rail. With conversion, vast acres of railway property will be available in the heart of cities for parking and also for multiple lane roads which will carry traffic non stop to or through centres of commerce.

If Southern Electric is such a good system, why are there only three express trains a day, and then only in the summer, between Brighton and Bournemouth ? The reason is that, unless there are multi-tracks it is impossible to run express and slow trains at the same time. They cannot overtake each other. On the Brighton/Bournemouth route buses could easily better the express train time of 2½ hours and the normal time of 3½ hours.

Turning to the letter of Mr. J. V. Walker, I would point out that the London Transport passenger is equally safe on a bus or a train. As to Brigadier Lloyd's "gross misuse" of statistics, he has included 101 trespassers and thirty-three others in the railway fatality figures because equivalent figures are already in the road accident total. The fact that in one case they are trespassers and in the other ordinary pedestrians is irrelevant. As to the 156 railway servants being industrial not rail fatalities, surely all accidents concerning "C" licence vehicles and firms' cars, &c., could be called industrial. I submit that Lloyd's statistics stand unscathed.

I think Mr. Walker is too keen when he details costs of complicated electronic guidance systems to cope with collapsing drivers, colour-blind tests and automatic safety devices to prevent vehicles passing danger signals. The American Turnpike figures are good enough without all the above safety items. The driver who covers 10,000 miles p.a. can expect an accident in his 116th year and a fatal one in his 5000th year. Exclusion of pedestrians, cycles, mopeds, &c., and a small vehicle speed differential with motorways built on the splendid rail beds are all that is needed to reduce road accidents.

Let us go ahead with a pilot stretch of conversion, as has been suggested by THE ENGINEER itself.

J. E. HUSON

Worthing,
Sussex,
February 10, 1961.

SIR,—Until there is an Urban Motorway leading into London from the residential areas of Surrey, it would seem that Mr. Harding is premature in saying that the motorist prefers the Southern Electric Railway to driving into London.

I would like to draw Mr. Harding's attention to the vast acreages of some London Stations—Waterloo 24½, Victoria 21¾, Kings Cross 15¾ and Euston 18. These great sites together with other stations and goods yards are so extensive that there are no less than 600 acres of railway property within 2½ miles, Charing Cross.

If this was opened up to road vehicles I am sure the motorists would be glad to forget the Southern Electric, and for those who did not have cars there could be an excellent bus service. This could be much more frequent than the trains, and very much cheaper, as the buses would share the maintainance cost of the routes with the cars and trucks, and so the permanent ways in their new role would far exceed the greatest expectations of their Victorian builders.

C. WILSON

Boroughbridge,
Yorks,
February 6, 1961.

SIR,—May I thank Brigadier Lloyd for his prompt and detailed reply to my letter. Now at last, we are getting down to something positive, instead of the airy-fairy arguments that have been bandied about in recent months.

As I understand it he would handle my particular problem by using *every* lane out of *every* London terminal station to clear the 500 super-buses in the period stipulated. I cannot help feeling, however, that his estimate of the lanes available is rather generous. Provision would surely have to be made for incoming traffic. The long-distance buses would have to come in from outlying garages, and there is the small matter of the suburban rush hours to be catered for, *at the same time*. Broad Street, Fenchurch Street and Holborn Viaduct stations can be counted out altogether, as they handle only an intense suburban traffic, and those of their lines that could be used for long distance traffic funnel into main routes from other termini not many miles out.

From detailed knowledge of the main lines available—and we are only talking of main line traffic at the moment—I make the number of lanes that could be set aside for long distance traffic not more than thirteen, as follows :

Paddington	Two
Marylebone	One
Euston	One
St. Pancras	One
King's Cross	One
Liverpool Street	Two
London Bridge (Brighton terminus)	One
Charing Cross } together	One
Cannon Street }	
Waterloo	One
Victoria	Two

This reduces the headway per lane to 1·2 minutes. To give airline comfort, with the "full restaurant facilities" forecast by another conversion enthusiast would mean not only super-buses, but plenty of clearance between each, so that if it did become necessary to slow down or stop, the rate of deceleration could be gradual—to avoid clearing the "restaurant facilities" from the tables. The sudden slowings and swervings ordinarily experienced in road travel would be quite unacceptable. In other words there would have to be a system of signalling to give prior warning to the drivers, and presumably some sort of control to ensure that buses ran in their scheduled lanes, and that the converted railways did not become a free-for-all. What does Brigadier Lloyd propose ?

O. S. NOCK

Bath,
February 11, 1961.

INDICATING THE FREE-PISTON ENGINE

SIR,—It may be of some interest to your readers to know that the method suggested by Mr. G. Walker in his "Note on Indicating the Free-Piston Engine" in your November 25, 1960, issue has been employed at the Battelle Memorial Institute. Our system, which is virtually identical in principle to that suggested by Mr. Walker, has been a powerful and reliable tool in the research and development programmes we have conducted on a number of single-piston, free-piston engine compressors.

In the indicating system used here, the motion of the pressure-piston assembly of a Dobbie McInnes Farnboro' indicator is transferred to a drum on which the indicator card is mounted. The drum, whose angular position is a function of reference pressure, is placed so that a stylus, firmly attached to the free-piston itself, moves in a path close to and parallel to the recording drum. We use clamped-diaphragm pressure pickups, of the MIT type, to obviate the objections Mr. Walker has cited against the standard Farnboro' balanced pressure pickups. In our work we have found that grounding (earthing) the engine and, therefore, the stylus, and raising the potential of the recording drum during sparking eliminated the necessity of carrying a flexible conductor to the reciprocating piston and resulted in a reliable system. In fact, excellent results were obtained by using a circuit with two spark gaps so that no moving conductors were required at all. In the two-spark system, one spark occurred at an unused portion of the recording drum rim and the other spark occurred under the stylus.

Battelle's work in the free-piston field dates back to 1955 and includes extensive research and development on both air compressors and Freon refrigerant compressors. Currently under development is a 3-ton (at air-conditioning conditions) single-piston machine for an F-22 system. Fuel for the engine section is natural gas (primarily methane) and gas injection is employed to prevent loss of fuel during scavenging. The fuel injector is operated pneumatically by pressure signals from the scavenge chamber so that mechanical complexity is held to a minimum.

A. W. CAREY JR.,

Associate Staff Engineer,
Mechanical Engineering Department
Battelle Memorial Institute,
Columbus,
Ohio.
January 26, 1961.

EDGE CRACKING OF A STEEL-BAND CONVEYOR

SIR,—Mr. E. C. Houghton is quite correct about the two equations referred to in his letter, your journal, February 3, 1961, page 167.

The attractiveness of a steel-band conveyor is its silent running, safe operation for underground conditions (less fire risk, safe to personnel, &c.), and its relatively small driving head. This was considered reason enough to try out one or two experimental installations underground. Considerable numbers of cable belt conveyors are used in British mines for long distance haulage. These conveyors require large driving heads, and quite elaborate driving arrangements to obviate differential stretch between the two wires. Wire replacements due to wear have been rather costly, and the belts with specially moulded vee-edges are much more expensive than a "normal rubber and fabric belt."

A review of belt conveyors with steel haulage members was published by D. S. Kedick and T. Furman, in *Colliery Engineering*, January, 1960, and Mr. Houghton might find some points of interest in this paper. Suffice it to quote here the operative introductory passage : "How to maintain the advantageous features of the belt and be able to extend its length, indefinitely if possible, is the challenging question conveyor designers have been trying to answer." The question is still open.

DR. T. FURMAN

Mech. Engineering Adviser
Process Development Department,
National Coal Board,
February 7, 1961.

LAND DRAINAGE AND WATER SUPPLY

SIR,—In a letter about "Land Drainage and Water Supply" in your issue of February 3, it is proposed to dig a Grand Contour Canal which shall be made to flow "on a single level" at a rate of 2000 cusecs. There must be many irrigation engineers who would dearly like to know how water is made to flow without a fall in level. Could we be informed where such a phenomenon is to be observed ?

F. NEWHOUSE

London, S.W.1.,
February 7, 1961.

Book Reviews

Ordinary Differential Equations and Their Solutions. By GEORGE M. MURPHY. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 64s.

DIFFERENTIAL equations are involved in most branches of science and engineering. Associated with the solution of a differential equation is the evaluation of an integral. This is a problem of integral calculus which lends itself to a systematic approach and tables of integrals are available. The task of actually solving the differential equation, that is the manipulation process that is required in order to reduce it to an integration, is far more difficult to treat systematically. There are a large diversity of types with various functions and combinations of differentials, variables and constants. It is not so easy to produce standard differential equations as it is to list standard integrals.

Professor Murphy has tackled this difficult task in an original manner. In his book he gives two alternative methods of solving differential equations. In Part I they have been classified into types and the main methods of obtaining the general solution of the different standard equations are given. Part II lists in tabular form 2315 differential equations with their solution arranged logically. There are interrelations between Part I and Part II. Part II comprises six tables which correspond with the main classifications in Part I ; an index is given which lists every equation in Part II according to the equation types in Part I.

The six main classifications of differential equations adopted in this book are as follows : First Order and First Degree (A1) ; First Order and Higher Degree (A2) ; Second Order and Linear (B1) ; Second Order and Nonlinear (B2) ; Order Greater than Two and Linear (C1) ; Order Greater than Two and Nonlinear (C2). In Part I the procedure is to subdivide these main classifications systematically into various general

LETTERS AND LITERATURE *(continued)*

types for which methods of solution are given. The sub-classifications may arise from the form of the equation—for example "independent variable missing"; the type may be an equation with a special name which has a standard form and solution—for example Ricatti's equation; subdivisions may depend on the method of solution—for example different changes of variable. Contained within these varied methods of solution is to be found a great deal of fundamental theory of differential equations. The use of the linear differential operator D is included. There is a short account of the use of Laplace transforms. A full treatment is given of the solution of Laplace's equation in eleven different co-ordinate systems. Special attention is paid throughout to equations with singular points. Methods of obtaining approximate solutions and series solutions are covered where appropriate. These are but a few examples to indicate the extent of the mathematics. It is restricted to ordinary differential equations and the many other varieties, such as partial differential equations, simultaneous differential equations and integro-differential equations have been excluded. Within this defined limitation a very comprehensive collection of methods of solution and the relevant theory are provided.

The author contends that he has not found an entirely satisfactory way of arranging the equations in Part II. However, he lists the general principles that he has followed. The equations of the first order and first degree are arranged in order of increasing complexity or rank of the coefficient of the differential. Increasing rank is taken as functions which are irrational, trigonometric, inverse trigonometric, exponential, logarithmic, hyperbolic, of more general type. The order of increasing rank for trigonometric functions is taken as the alphabetical order of the functions. Specific constants have lower rank than general constants; a positive sign has lower rank than a negative. These general rules help in the search for a particular equation among the tabulated lists and the reader will find the process becomes easier as he gains familiarity with the tables by repeated use.

An extensive bibliography is given which contains both classical treatises and current textbooks on differential equations. Although the majority of the books referred to have been published in the U.S.A., some notable British and European publications are included. An introduction at the beginning explains the procedures and gives the notation adopted, and a full index at the end completes the book.

In the preface the author explains that he is a chemist by training and profession. This is significant for it has no doubt influenced the purpose and style of his book. Professor Murphy states that it is written to help in the solution of differential equations. It certainly achieves its aim, and scientists and engineers will find it of great usefulness. It is, however, a book which has more than a utilitarian value. It is packed with important material on the theory of differential equations; it contains solutions of historial interest; it includes some solutions for the sake of their ingenuity or for the neat form of the result. Although the author professes no pretence to mathematical elegance and apologises for any faults in this respect, there is plenty in this book for the mathematically inclined who want more than the mere solution to an equation. There results a very interesting and readable book as well as a useful one. It will serve a wide range of readers and is highly recommended.

Fundamentals of Digital Instrumentation. By D. S. EVANS, M.I.E.E. Hilger and Watts, Ltd., 98, St. Pancras Way, London, N.W.1. Price 7s. 6d.

WHILE dealing mainly with shaft-driven digitisers, this monograph provides a useful introduction to the general principles of converting analogue information into digital form, and the practical advantages in storage space and economy in components which accrue from using the binary scale. The construction of coding scales is described and explained by diagrams, and some notes are given on a mechanical (or contact) digitiser, and an optical digitiser in which the scale is in the form of clear and opaque rectangles on glass, producing coded outputs from a row of photocells. Subsequent sections deal briefly with decoding, cycling, sampling and storing, and time sharing. The final chapter surveys some applications of digitisers of various kinds. In its thirty-nine pages, the monograph provides the foundation necessary to the understanding of digital conversion methods in general.

F. W. Lanchester. By P. W. KINGSFORD. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1.

THE sub-title of this book is "The Life of an Engineer," and other engineers should take note that this is an exact and exclusive description; the subject is *not* Lanchester's "life and works." Nothing more, in this respect, could have been attempted by this author, who describes himself as not trained in the disciplines of science and technology; there is, however, much to be learnt from this account of the injustice with which Lanchester was treated not only by those who consulted and employed him, but also in courts of law.

Ordinary motorists and non-technical people interested in the development of aircraft may well find the book makes interesting and entertaining reading. Punctuation is a personal matter. We found some of the author's odd. Even those without technical ability will observe some shortcomings of the proof-reading.

Berechnung von Gusseisernen Emaillierten Druckbehältern. By G. MATZ and P. Gayer. Vol. 7 of *Verfahrenstechnik in Einzeldarstellungen*. (Editors: J. Spangler and W. Matz.) Berlin-Göttingen-Heidelberg: Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3. Price, DM. 37.50.

WHILE much literature is nowadays available concerning the chemistry of enamels and its influence upon physical characteristics, much less is known with regard to the stresses which arise in enamels. This is true both as regards the experimental as well as the theoretical approach, except for some researches into thermal stresses mostly based on small samples. The present monograph deals with the stress distribution in the enamel of a cast iron pressure vessel with a volume of 6000 litres. Vessels of such size are of considerable industrial importance. Measurements by resistance strain gauges were carried out of the strains in the layer of enamel and in the external skin of the metallic support. These measurements were compared with the results obtained mathematically. It is stressed, however, that both the experimental method and the theoretical solution are quite generally valid and can readily be applied to other kinds of pressure vessels.

The method of strain gauge measurements is critically reviewed, in particular with regard to its practical application to a piece of equipment which had been exposed to actual working conditions. Of great importance also is the matter of the physical constants of both materials. Evaluation of the results of measurements by statistical methods shows that besides a determination of the direction and magnitude of the principal strains, it is possible to make certain deductions concerning inhomogeneity of the cast iron employed.

A major part of the book is devoted to a full and critical treatment of the mathematical theory, with certain novel extensions; a full calculation of the stresses arising at any point of the vessel under the influence of internal pressure is here given for the first time. All procedures lend themselves to programmed machine calculations, so that in future this part of the work can be speeded up greatly.

Consideration is also given to thermal stresses, and some mathematically complex problems are broached; of particular importance is the synoptic discussion of various flange theories.

Mehrspindelautomaten. By HANS H. FINKELNBURG. Berlin–Göttingen–Heidelberg: Springer-Verlag, Berlin–Wilmersdorf, Heidelberger Platz 3. Price D.M.49.50.

SINCE the first publication of "Multi-spindle Automatics" in 1938, this field has undergone a very extensive development. Full exploitation of the possibilities which now offer themselves presupposes a thorough understanding of the various designs now available on the market, as well as the selection of optimum tooling and careful preparation of the job. All these aspects are dealt with in the present second edition, which has been thoroughly revised and brought up to date. After discussing the various basic designs and their relation to the kinds of workpiece for which they are particularly suited, the author deals with the special abilities offered by multi-spindle automatics as compared with related machine tools such as turret lathes and single-spindle machines. Closely connected with this topic are questions of economy, accuracy, setting, and output capacity, and these are discussed at this point, after which there follows a detailed treatment of designs with rotating and stationary workpieces, tooling and fixtures.

Books Received

Chemical Engineering Practice. Vol. 10. *Ancillary Services*. By Herbert W. Cremer and Sidney B. Watkins. Butterworths, 4 and 5, Bell Yard, London, W.C.2. Price 100s.

Die Drahtseile in der Praxis. By R. Meebold. Third revised edition. Berlin-Göttingen-Heidelberg: Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz, 3. Price DM.12.

Absperrorgane in Rohrleitungen. By Walther Volk. Vol. 18 of *Konstruktionsbucher* (Editor: K. Kollmann). Berlin-Gottingen-Heidelberg: Springer-Verlag, Berlin-Wilmersdorf, Heidelburger Platz, 3. Price DM.25.50.

SHORTER REPORTS

"Jason" Reactor Operated at 100kW

THE "Jason" nuclear reactor, built and owned by Hawker Siddeley Nuclear Power Company, Ltd., Langley, Slough, has recently been operated experimentally at 100kW, which is ten times the rating for which this research reactor was originally designed. The work which gave rise to this series of operations at 100kW was part of the development programme on advanced types of "Jason" reactor now being undertaken at Langley. The experiments were carried out in accordance with the terms of the Ministry of Power's licence for the company's nuclear site, and at the same time provided useful information in support of the safety regulations for which the Ministry is responsible to the general public. The ability to attain these high ratings is of great importance to the universities and research organisations who intend to operate research and training reactors at home and abroad. The higher powers enable both the range and accuracy of the experiments to be increased, and at the same time they improve operating economics.

Operation at 100kW was part of a series of tests devised to yield information on the safety characteristics of reactors now in the design stage. Information was obtained on two important working conditions: first the effect of pump failure during operation at 100kW; and secondly, the removal of decay heat by thermal convection of air, following the reactor "scram" (with water dumping) from full power.

After preliminary trials three runs were made at 100kW, each of about twenty minutes duration, the cooling supply being as for 10kW. In two of the runs, the coolant supply was completely interrupted so that the behaviour of the reactor could be observed. When no attempt was made to compensate for the rise in temperature, the power quickly fell and the reactor stabilised out at 10kW. When the control rods were withdrawn to compensate for temperature rise, the power remained steady until they were fully withdrawn, and the power then fell to about 20kW. For the final run, the cooling supply was kept at a constant four gallons per minute during the whole of the run. The reactor was then "scrammed" from 100kW and the rapid removal of heat by air convection was observed; no serious overheating of the fuel elements was detected.

Historic Engine Drawing Competition

IN connection with the Commonwealth Technical Training Week, May 29–June 4, 1961, Nuneaton Museum is organising a competition for the best set of drawings of the Newcomen atmospheric engine which was installed at Griff, near Nuneaton, in 1712. Thomas Newcomen, whose invention of a pumping engine of a kind far more reliable and of greater scope than anything previously existing, came at a time of crisis in the mining industry, offered to erect one of his engines at Griff in 1711, but failing to reach agreement with the colliery owners built his first machine near Dudley, a few miles away, in 1712. In comparison with other pumping equipment then existing it was very advanced, and was immediately successful. It is recorded that a Newcomen engine was also in use at Griff in 1712, and from these two pioneer installations the fame of the inventor spread rapidly, with the result that Newcomen engines were erected in many parts of Great Britain and abroad. The engine solved the immediate difficulty facing the mining industry—that of pumping out the water which increasing depth brought with it, and paved the way for the later developments, by James Watt and others, on which the present industrial economy is based.

A contemporary engraving, by Henry Beighton, of the original Newcomen engine exists, and a photographic copy of this engraving will be supplied to those entering the competition. Further information giving the principal parts of the engine and its general dimensions is also available, and a prize of £20 is offered for the best set of drawings based on these particulars together with any further data which competitors can discover by their own researches. Two consolation prizes of £5 each are also to be awarded for meritorious work. The competition is "open" in the fullest sense of the word; and the closing date for entries is May 14, 1961. Full details can be obtained from Mr. R. K. Dunham, Curator, Museum and Art Gallery, Riversley Park, Nuneaton, Warwickshire.

Availability of Calder Hall Reactors

DETAILS of the satisfactory performance of the Calder Hall and Chapelcross nuclear reactors have been given from time to time. For example in the sixth annual report (1959-60) of the United Kingdom Atomic Energy Authority it was stated that the thermal output of the reactors had been increased by 15 per cent above the design capacity; and that, including the scheduled shut-downs for refuelling the reactors, an operating availability of more than 80 per cent was being achieved.

Further details of the past twelve months' operation have now been given by the Atomic Energy Authority. It is stated that one of the Calder Hall reactors operated at full electrical output continuously for 95·6 per cent of the whole period between February 2, 1960, and January 31, 1961, after which it was shut down for routine maintenance and changing of fuel elements. Between the dates mentioned there were no shut-downs caused by fuel element failure.

An analysis of the periods during which the reactor was not on full load is tabulated below, to show the causes of "lost" time and the comparative effect of each cause:

	Per cent
Experimental work	2·5
Scheduled maintenance of ancillary equipment	0·7
Unscheduled blower maintenance	0·6
Unscheduled maintenance of other equipment	0·4
Special tests on fuel elements	0·2
Total	4·4

It is significant that unscheduled maintenance accounted for less than a quarter of the total and was responsible for only 1 per cent "lost" time at full load.

Rockets on Exhibition

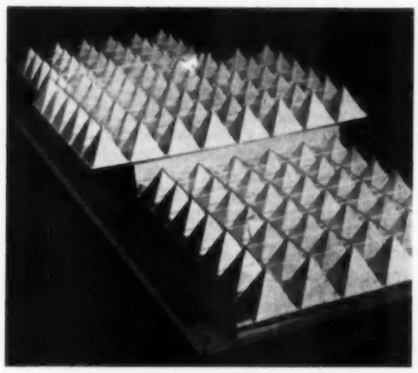
A SMALL exhibition of research rockets is now being held in the Science Museum, South Kensington, continuing to March 10. Such rockets are fired to a height of nearly 50 miles: they can be used to take samples of the atmosphere as they travel, and to transmit back to earth measurements of the temperature, pressure and radiation. When clear of the earth's atmosphere they can take photographs of the sun or of cloud formations over the earth. The methods of firing and the results obtained from photographs are explained on screens.

The exhibition, which has been lent by the United States Navy, includes five rockets of various sizes up to 14ft in length, and a nose-cone which has been recovered by parachute after firing to more than 100,000ft.

Building for Architectural Congress

NEXT July, the sixth congress of the International Union of Architects will be held in London at the Royal Festival Hall. The theme of the congress will be "New Techniques and Materials—Their Impact on Architecture," and one illustration of this theme is to be in the form of a special exhibition building erected temporarily at the South Bank. One aspect of this building is of special interest to engineers, viz. its roof structure.

The roof will consist of tetrahedra of light alloy sheet, each one 8ft square at its base, arranged as shown in the illustration of the model of the building. As can be seen, the tetrahedra have their apices uppermost and interconnected by a grid of bracing members. The sheet forming their surfaces is to be of B.A.60 (NS3) alloy and the bracing grid of 25WP alloy, extruded as 2½in o.d. tubes ⅛in thick. A cruciform member forms the joint at each corner at the base, the sheets being lapped round it. An adhesive may also be used here to complete the joint. The roof structure is in fact a combination of the concepts of stressed skin and of a space structure; the tensile strength of the sheet is utilised. The raised central section spans 48ft without internal columns, but there is a deep truss along the side wall which can be seen in the illustration, and which separates the raised central roof from the lower roof in the foreground. The roof is to be carried on tubular steel stanchions. Its weight will be of the order of 2 lb per square foot. Uplift due to wind will exceed its deadweight, and the truss mentioned above will thus have compression in both its top and bottom booms, according to conditions. The architect for the building is Mr. T. Crosby, A.R.I.B.A., and the structural engineers Messrs. F. J. Samuely and Partners, in consultation with Dr. Z. S. Makowski.



Model of architectural congress building with roof of light alloy sheeting arranged as a series of tetrahedra

Conversion of Troopship "Dunera"

THE M.S. "Dunera" was built by Barclay Curle and Co., Ltd., to the order of the British India Steam Navigation Company, Ltd., for charter to the Government as a troopship and modified in 1951 to conform with the latest requirements for trooping. After the completion of her charter the ship will, after disembarking and de-storing, proceed to the Hebburn establishment of Vickers-Armstrong, Ltd., where the ship will undergo a comprehensive conversion to equip her for her future employment on educational and holiday cruises for young people. In its new role the liner will offer the advantages of travel while allowing young people to continue their normal course of studies. When converted the "Dunera" will provide accommodation for 200 cabin class and 800 dormitory class passengers, each having separate public rooms and amenities. The cabin class accommodation is intended for adult persons associated with education, and will not be available to the general public, while young people will occupy the dormitories. Six lecture rooms fitted with desks, cinematograph equipment, projectors, &c., and able to seat a total of 450 will be available.

SHORTER REPORTS *(Continued)*

Bridge Bearing for Heavy Loads

AN "extra high-tensile steel bearing" of compact design known as the "Hi-Load" bearing is now being manufactured by Joseph Westwood and Co., Ltd., in addition to that firm's standard ranges of bridge bearings in mild steel and high-tensile steel. It is claimed that the new bearing is capable of sustaining a load many times that previously used for single rollers in this country.

The single roller, which has been standardised at 4in diameter, and the top and bottom plates immediately in contact with it, are made from heat-treated alloy steel. Tests have shown that these rollers and plates can withstand a load of 65 tons per lineal inch without evidence of surface cracking and without undue permanent distortion. A working load of 25 tons per inch run has therefore been adopted, which compares with 2 tons per inch for steel to B.S.15 and 2·8 tons per inch for H.T. steel to B.S.968 for the same size roller. The bearings can be designed to suit the loads and conditions of each individual application and are enclosed in grease boxes and packed with grease.

According to Herz's theoretical work, the criterion applied is that bearing resistance is proportional to the square of the hardness number of the bearing surfaces. These rollers have a Brinell hardness of 500, for a depth of about 1¼in from the circumference.

[Reply Card No. E2521]

Micro-Measuring Instrument

BASICALLY a projection microscope, the "Projectina" micro-measuring instrument is designed to accept a very wide range of accessories which enable it to be used as an eyepiece type microscope with a magnification range of ×7 to ×3000; as a projection microscope, using either an integral ground glass screen or a wall screen; or as a comparator. For the latter purpose a double optical system can be provided, giving images of two objects side by side on the same screen. A combined photographic plateholder and

The "Projectina" being used for examination of a small metal component

ground glass focusing screen is available, and attachments can be provided to enable various 35mm cameras or the Polaroid Land camera to be used with the instrument.

Specimens for examination are normally carried on a compound table, with micrometer adjustment in both directions, reading to 0·5 micron. Other specimen carriers are available for such purposes as continuous surface examination of textile yarns, threads or wires. By duplicating the thread-carrying attachments it is possible to carry out continuous inspections and comparison of two threads, the images being projected side by side on the front viewing screen. Lighting is by a built-in system, giving a choice of transmitted and/or surface light, with projection on light or dark fields. Polarising equipment is available for the light source, as well as various colour filters. A feature common to all the accessories in the range is the ease and simplicity with which they can be interchanged.

The "Projectina" is made by Projectina Optical Works, Alstraetten IX, Switzerland, and is marketed in Great Britain by Mr. R. G. Macfarlane, 8, Montgomerie Terrace, Skelmorlie, Ayrshire, Scotland.

[Reply Card No. E2522]

Cargo Handling System

COLLABORATION between Clarke, Chapman and Co., Ltd., and MacGregor International has resulted in the development of the "Algonquin" loading/unloading equipment which marks an advance in the application of mechanisation to cargo handling. The equipment, which has a capacity range of from 200 tons to 500 tons per hour, in addition to handling bulk cargoes, can be adapted for use with pallets or containers. Of robust welded box girder construction, the unit consists of a main bridge, fitted with a telescopic bridge, which can be lowered by means of hydraulically-operated hinged supporting arms, and the whole is carried on deck-mounted rails to give fore and aft movement when driven from the common electro-hydraulic system. All the mechanical and electrical gear is totally enclosed, and for reliability and the avoidance of complex gearing and transmissions the holding, closing and traversing operations are powered by separate motors. These are connected to the gear trains, which are mounted on ball or roller bearings, through flexible couplings. All the control gear is mounted on the bridge or in the driver's cab.

A Priestman walking pattern grab is used for bulk cargoes; the grab is traversed by a wire rope and discharged into a collapsible steel hopper and on to vibratory feeder. This moves the material upwards on to a telescopic conveyor which is supported from the telescopic bridge and is able to discharge to points at distances up to 100ft from the ship's side. Using the main and telescopic bridges bulk cargoes can be discharged by grab up to 14ft outboard, while for palleted cargo or cargo containers, the equipment permits discharge at 22ft from the ship's side.

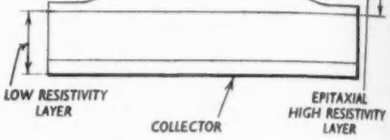
[Reply Card No. E2523]

Silicon Epitaxial Transistor

A SILICON mesa transistor announced by Texas Instruments, Ltd., Manton Lane, Bedford, is stated to be the first commercially available silicon transistor manufactured by the epitaxial process. This transistor, at present designated XB26, has a switching time of thirty nanoseconds and will give useful amplification up to 200 Mc/s. While it is expected to find its widest application in electronic computers, the new transistor can also be used for a wide variety of small signal applications.

The epitaxial process consists of the carefully controlled growth, by vapour deposition, of a thin layer of high resistivity material on a substrate of very low resistivity material. The emitter and base layers are then formed by diffusion into the thin epitaxial layer. This structure is shown in the accompanying drawing. With the normal diffused transistor, the base and emitter layers are formed by the diffusion of impurities into a homogeneous wafer. The remainder of the wafer, which forms the collector region, must have a reasonably high resistivity to obtain a satisfactory collector breakdown voltage; at the same time it should have as low a resistivity as possible to obtain a low collector saturation resistance. Thus, with the conventional structure, a compromise is necessary.

With the epitaxial construction, the original silicon wafer is of very low resistivity and a thin epitaxial layer of high resistivity is deposited on to it. Base and emitter regions are formed in the epitaxial layer by the diffusion of impurities as in the conventional device. The actual



Epitaxial mesa construction

transistor function is confined to the three upper layers, with the low resistivity substrate serving only as a platform or handling mechanism for ease of fabrication.

By avoiding the previously enforced compromise on collector resistivity, the transistor design can be optimised, and the epitaxial silicon transistor promises a considerable improvement in bottoming voltage, which becomes independent of temperature, together with faster switching, a higher operating frequency and improved linearity of gain with current and temperature.

[Reply Card No. E2524]

Continuous Weighing System

BOARD OF TRADE approval has been given to the "Transweigh" system for continuous weighing of belt-conveyed solids, which has been introduced to the United Kingdom and Western Europe by the Electronics Division of Murphy Radio, Ltd., Welwyn Garden City, Herts. The "Transweigh" patent is based on the use of a short weighing carriage and resistance load cell. In one form the output of the cell is the product of belt speed and material load, since the voltage applied to the cell is derived from a tacho generator driven by the belt system, and is modified by the varying resistance of the strain gauge wires in the cell which form the weighing element. This voltage is fed to a potentiometric recorder which indicates and records the instantaneous flow rate in appropriate units. Total weight is also recorded on a digital counter built into the instrument. In an alternative equipment speed signals are transmitted by a selsyn drive to an integrator which receives separate weight signals from the load cell and provides similar flow rate and total weight indications.

When using the tacho generator system, the rate-of-flow signal can be fed to conventional instrumentation to provide many kinds of automatic control.

[Reply Card No. E2525]

Extended Range of Engines

WE have been informed by Davey, Paxman and Co., Ltd., that, following exhaustive tests, pressure charging has been applied to the smaller engines in the Paxman 7in bore range of engines, namely the Mark 4, 6, and 8RPH four-stroke, vee-form units of 7¾in stroke. The complete range of the company's smaller engines is now as follows: 4, 6, 8 RPH normally aspirated 100–366 b.h.p.; 4, 6, 8 RPHX pressure charged 120–406 b.h.p.; 4, 6, 8 RPHC intercooled pressure charged 132–454 b.h.p.—all at operational speed of 750 to 1500 r.p.m.

[Reply Card No. E2526]

Inclinable Presses

THREE models of the inclinable open-backed "Torc-Pac" presses to the designs of the Clearing Division of U.S. Industries Inc. of the United States are now being built in this country by Vickers-Armstrong (Engineers), Ltd., and marketed by the Rockwell Machine Tool Company, Ltd., Welsh Harp, Edgware Road, London, N.W.2. The two smaller models of these machines, with respective capacities of 22 tons and 32 tons, are driven by continuously rated 2 h.p. motors, whilst the largest 45 tons capacity machine has a continuously rated 3 h.p. motor drive. A choice of fixed speeds and variable speed drives are available, the maximum rated speeds being 225 strokes per minute for the smaller presses and 150 strokes per minute with the largest machine. If required 45-ton capacity presses can be supplied with fixed speeds of 75, 90 or 122 strokes a minute and driven by a 5 h.p. continuously rated motor. In relation to press capacity any one of four stroke lengths can be provided up to a maximum 4in, 5in and 6in. Standard or high bodies are available for all models, and the 32-ton and 45-ton presses can be supplied with a standard 8in or 9½in deep throat or special 10½in or 12in deep throats.

These presses are of welded steel plate construction and the complete drive unit, to be seen in section in one of our illustrations, is mounted between the side frames. The air-operated friction clutch and brake in the drive are mechanically interlocked to prevent simultaneous engagement. When pressure air is admitted the brake is released and the clutch engaged; upon the air being exhausted the clutch is released by spring pressure and the brake applied. In the event of failure of air or power supply the drive is automatically braked by the spring loading. The friction plates of sintered bronze, which run in oil, are not subject to wear and are unaffected by high temperatures.

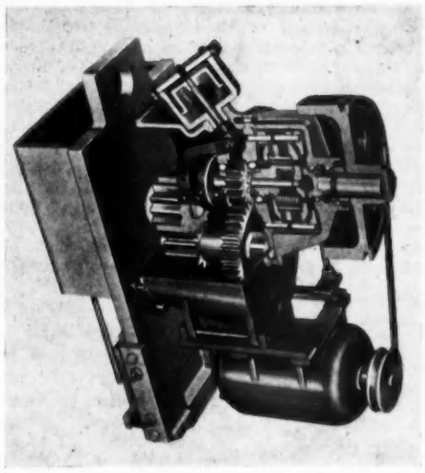
Inclinable power press with "Torc-Pac" unit drive

Drive from the motor is transmitted by vee belt to the flywheel and clutch, and from the clutch shaft through a reduction gearbox to an eccentric shaft running in anti-friction bearings. The placing of these bearing supports immediately adjacent to the eccentrics reduces bending moments. The shaft is extended through the front of the housing to provide a power take-off for slide feeds, &c., and a stroke-indicating arrow is provided to show the position of the eccentric. A limit switch fitted above the extension is operated by an adjustable cam and is used for stopping the press at various speeds with the slide in its top position.

A thick plate is fitted to the forked lower end of the pitman and a pitman extension through this cross piece is locked in position by nuts at the top and bottom. The deep upper locknut is marked in 0·001in increments to facilitate accurate slide setting—the range of slide adjustment being from 2in to 2½in depending upon the size of the press. With this pitman construction it is claimed that the load when the press is working is applied over all the threads of the large adjustment nut.

The three models of these presses now being built have respective bed and bolster sizes of 21in by 11in ; 24in by 15in ; and 28in by 18in, with bed openings of 9in by 5in ; 11in by 8in ; and 14in by 11in. Inclination of the presses is effected by rotating an adjusting screw with a wrench—the 22-ton and 32-ton machines can be inclined up to 30 deg. and the 45-ton machine up to 25 deg.

A selector on the control cabinet at the side of the machine has four settings for continuous, off, inch and single stroking ; the operator's run and stop buttons are mounted at the front of the



"Torc-Pac" sealed unit drive fitted to inclinable press

bed and additional controls such as foot switches can be plugged into the control circuit. The complete drive unit is a sealed assembly which is not designed for repair by a user but can be changed through a replacement service when necessary and, all of its parts running in oil, it is stated to have a long effective service life. Lubrication of parts such as the eccentric shaft bearings, pitman bearings and slides is effected from a central point on the press frame and can be carried out by oil gun or a manually operated or an automatic pump.

[Reply Card No. E2531]

Tanker Machinery Installation

"THE Design and Layout of a 22,000 s.h.p. Tanker Machinery Installation" is the title of a paper which was read by Mr. J. B. Main before the Institute of Marine Engineers on February 14 and is summarised below. The paper outlines the approach made to the design and layout of turbine machinery for a 65,000 tons deadweight tanker and emphasises those points where there has been a departure from recent general practice. Only a barely adequate number of auxiliaries are provided for in the specification, since it was felt that the balance of capital should be assessed on a basis of rising maintenance costs. It is stated that the economic logic of the design is based on oil fuel costing £6 per ton, 320 days per annum at sea, and capital charges of the order of 14 per cent on the initial investment.

A steam pressure of 600 lb per square inch gauge was adopted because of proven performance, and the wish to reduce the chance of joint and valve leakage, while the reduction of the risk of corrosive attack and the avoidance of the use of special steels are quoted in support of the adoption of a steam temperature of 900 deg. Fah. Reliability was considered to offset any savings in the fuel ratio effected by higher pressures and temperatures. Heat balance diagrams are included ; the adoption of non-condensing turbo-generators and a steam turbine drive for the single main circulating pump is justified and figures are given relating to the comparative costs involved by the adoption of other arrangements. Main boiler plant, consisting of two variable superheat units each having an evaporation ratio of 80,000 lb per hour, is discussed : the increased operating costs occasioned by selecting a funnel gas temperature of 335 deg. Fah. are thought to be offset by savings in weight and maintenance charges. A table gives the build up of air and gas resistance components upon which the f.d. fan capacity was decided at 32,000 cubic feet per minute against 20in water gauge, representing a head margin of 140 per cent. The oil fuel burner design adopted is stated to be one which will operate as a straight mechanical atomising unit on full load and as a steam assisted atomising unit for manoeuvring and harbour conditions.

The engine specification is given as the development of 22,000 s.h.p. at 108 propeller r.p.m. with steam at 570 lb per square inch gauge and 880 deg. Fah., and it is noted that a Pametrada double casing h.p. turbine design was adopted. The paper examines design questions concerning turbo-generators, feed pumps, and main circulating pumps and then continues with points related to machinery layout, and to requirements for a good standard of habitability. An appendix to the paper sets out the principal particulars of the auxiliary machinery and equipment incorporated in the design.

Electronically-Controlled Weighing

EQUIPMENT for the electronic control of materials blending has recently been marketed by Electroweighers (Birmingham), Ltd., Moseley Street, Birmingham, 12. One of the materials is weighed on an electronic continuous belt weigher. Signals from the weigher control unit are fed to an electronic sampler and memory unit. The delayed signals from the memory unit are then used to control the excitation of a vibratory feeder which supplies the required amount of a second material on to another conveyor which carries both materials.

The weighing medium is a linear inductive load cell, from which voltage signals are fed to a memory and sampler unit which registers average load and retains the signal for a time of up to forty-five seconds before operating a servo-motor driving a toroidal transformer. The voltage output from the transformer supplies variable excitation to the vibrator feeder, which in turn varies the flow of the second material. The equipment can be used in any situation where mixing and blending are required. Other applications can be arranged to meet requirements.

[Reply Card No. E2533]

British Programme for Seismic Research

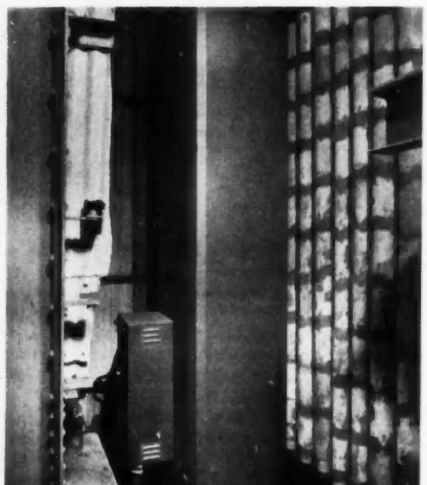
IT will be recalled that the United Kingdom Government recently announced its intention of carrying out a programme of seismic research on the detection and identification of underground nuclear explosions, in connection with the work of the conference on nuclear test control at Geneva. We learn that this programme is now being planned in detail by the United Kingdom Atomic Energy Authority. An operational centre for seismic work is being established in a converted country house a few miles from Aldermaston. The research programme will entail the firing of "conventional" explosive charges but no nuclear explosives will be used. Some of the explosions will probably be arranged to take place in disused mines and quarries. Others may take the form of the firing of charges dropped from Naval vessels at selected points in the English Channel. Studies are being made to find areas suitable for the siting of seismic measuring instruments.

SHORTER REPORTS *(Continued)*

Infra-Red Drier for Ladle Stoppers

IT is important that the cement joining the short refractory sleeves on steel works ladle stoppers shall be correctly and uniformly dried if the stoppers are to give satisfactory service. Incorrect drying can result in failure of the stopper and the loss of large quantities of molten metal. A common way of drying the made-up stoppers is to hang them near to a furnace, or to place them in a gas-fired oven.

At the Clydebridge Steel Works, Cambuslang, of Colvilles, Ltd., stoppers for 90-ton to 150-ton ladles are dried in an infra-red oven designed and built by The General Electric Company, Ltd., Kingsway, London, W.C.2. The oven is built up from standard sheathed wire element reflector units in a vertical sheet metal casing. It has an electrical loading of 56kW. As the stoppers are made, they are lifted to a vertical



Ladle stoppers entering drying oven

position by a small electric hoist block and hung on an overhead conveyor. Up to ninety stoppers can be carried by the conveyor, which takes them, three at a time, into the infra-red oven. Here they remain for twenty minutes or thirty minutes depending on the stopper diameter. On emerging from the oven the stoppers are completely dry and ready for use. They are lifted from the conveyor by overhead crane and placed directly inside the ladles in which they are to be used.

[Reply Card No. E2541]

Two-Level Roundabout Proposal at Vauxhall Cross, London

THE London County Council's Roads Committee has proposed a scheme, to cost about £3,000,000, for the improvement of the Vauxhall Cross intersection, Lambeth (i.e. the intersection at the south end of Vauxhall Bridge) by the provision of a two-level roundabout. It is hoped that work will begin in 1965.

Six main roads meet at the intersection and although complementary one-way working at Harleyford Road and Kennington Lane reduces the effective number to five, there are still twenty different traffic streams to be provided for. During peak periods, 6500 vehicles an hour pass through the intersection. Various methods of improvement have been considered, including a single roundabout, a flyover, or underpass and roundabout, but they have all been rejected because they would quickly become inadequate.

The scheme which is now proposed consists of a three-way flyover forming a small triangular roundabout at about the same level as the existing railway viaduct, above a larger surface roundabout. The upper roundabout will deal with traffic between any two of the three roads, Vauxhall Bridge, Albert Embankment and South Lambeth Road, and the surface roundabout with the remaining traffic. The scheme is estimated to have a capacity well above present requirements.

By starting the ramp from Vauxhall Bridge before the bridge approach drops to the level of the lower roundabout, and by skilful modification of the gradients of the present roads, it will just be possible to get the upper roundabout in without interfering with the railway viaduct or having to incur extra expense in widening Vauxhall Bridge over the river, the L.C.C. states. It will, however, be necessary to lower the roads on either side of Vauxhall Bridge foot to enable vehicles to pass under the road joining the bridge to the upper roundabout. The supports of the upper roundabout will pose problems of structure and design and their exact position cannot at the moment be determined. The full width of Kennington Lane under the railway viaduct will be required for the carriageway and the footpaths will have to be diverted through adjacent railway arches. Parliamentary powers for the compulsory purchase of land and the execution of the works are to be sought. Detailed planning of the scheme is not yet far advanced.

Heavy-Lift Vessel "Adventurer"

ON February 10, Mr. C. Stephenson presented a paper with the title "The Heavy-Lift Vessel 'Adventurer'" before the North East Coast Institution of Engineers and Shipbuilders; it is briefly summarised below. The paper describes the development of the design to provide adequate deck space for heavy deck loads, to accommodate a heavy lift derrick and to satisfy certain specified conditions of trim as dictated by the cargoes to be carried. Calculations are included covering the determination of the metacentric height required to meet the requirements of lifting a load of 180 tons at an outreach of 17ft overside with an angle of heel not exceeding 12·5 deg., and the beam necessary to provide the necessary degree of stability. The paper gives the principal characteristics and discusses structural design, and there are sections devoted to details of deck girders, hatches, cargo handling and stowage facilities. There are notes upon resistance and propulsion tests, together with data of the hull form, followed by a description of the heavy-derrick arrangements. The basic requirements for the derrick design are stated, also the specification of the steel adopted for the construction of the raked derrick posts, together with the system of forces acting on the posts. Other descriptions in the paper apply to the derrick heel socket and bearing ; the boom, cargo and span tackles ; guidance of the rope systems ; swinging through of the derrick ; lifting and cross traverses and the heavy lift winches. A final section deals with the tests carried out on the derrick and gear, and includes a tabular statement of weights of the equipment.

Data Logger and Alarm Scanner

A TRANSISTORISED equipment (type 300) for data logging and alarm scanning, with a capacity for up to 1000 input channels, is announced by Microcell Electronics Division, Blackwater, Camberley, Surrey. Any transducing element which gives a d.c. output signal can feed into the equipment, or a.c. devices and pneumatic transducers can be used via converters. Scanning is controlled by a programme unit which sends pulses to the signal sampling units, the latter being built up to meet the total channel requirements of the system. Each sampling unit contains a five-stage ring counter which is stepped by the incoming pulses and on each step calls in the appropriate sampling relay, or relays. The latter are dry-reed sealed relays with gold-plated contacts and are stated to have an extremely low noise level so that microvolt signals can be handled without degradation. Data are presented in digital form through an analogue/digital converter.

Alarm levels can be set up for individual channels if required, or a particular figure applicable to several channels may be set up and made to apply to those channels by means of pin board connections. The alarm detection system is digital, the decimal figures set up being compared directly with the decimal figures appearing at the output of the analogue/digital converter. If required, an alarm indication which has been printed out will not be repeated, the channel concerned being quiescent on subsequent scans until it returns to normal. This function is performed by bistable memory circuits operating through relays. Spare contacts are available on the alarm relays for auxiliary and plant control purposes. The annunciator panel consists of groups of electroluminescent strips, one of which flashes, together with a master flashing lamp, when an alarm is detected. Acknowledgment of the alarm by means of a push button extinguishes the flashing lamp and switches the channel indicator to a continuous glow.

[Reply Card No. E2544]

Integrally-Moulded Cable Join

To provide mobile weatherproof and dustproof socket outlets on industrial sites and installations, an integrally-moulded cable join of the form illustrated is manufactured by Nettle Accessories, Ltd., Warren Street, Stockport, Cheshire. The joins are available with one inlet and either two or three outlet cables, and can be supplied in either rubber or neoprene. The inlet cable can be terminated in any plug suitable

Two-way moulded join for three-core cables

for the user's supply outlet, and the outlet cables are terminated normally by Nettle 5A weatherproof connectors.

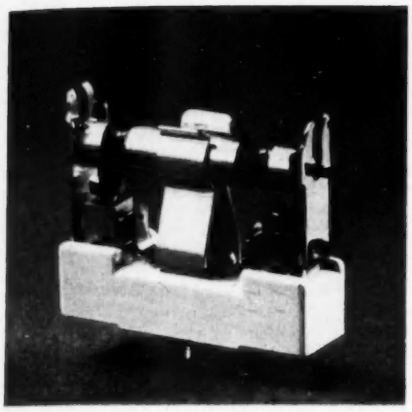
The junction between the cables is moulded strongly inside a block of rubber or neoprene, with adequate cable clamping for mechanical strength under arduous conditions. Lengths of both inlet and outlet cable can be varied to suit individual conditions. The cable sizes available are three-core cable 40/0076 and 70/0076.

[Reply Card No. E2545]

Gas-Filled Line Protector of Ceramic and Metal Construction

HAVING developed new constructional and sealing techniques, the Telephone Apparatus Department of A.E.I. Telecommunications Division, Woolwich, London, S.E.18, now offers a gas-filled line protector, for telecommunication equipment and cables, using only ceramic and metal parts. It is a three-electrode device, designated type-16, and is only a fraction of the volume of the conventional two- or three-electrode equipment, yet is designed to give improved performance. Moreover, it can replace two or three two-electrode protectors.

Dimensions of glass-enveloped types have remained constant due to limitations (imposed by the use of glass) in maintaining suitable current/surge handling capacity, and, to some extent, to the standardisation of mounting devices. A property, hitherto unexploited in gas-filled protectors of conventional form is that, through a new electrode arrangement, a severely overloaded gap tends to become short-circuited, thus maintaining safe conditions on the line. Now, however, the use of high-temperature-brazed, ceramic-to-metal seals permits the envelope to run at high temperatures, allowing maximum current-handling capacity for its particular size. The dimensions of the new A.E.I. component are 1 1/16in long and 3/8in diameter (49mm by 9mm).



Metal/ceramic gas-filled line protector (A.E.I. type-16) in an A.E.I. type-53 unit mounting. The unit provides a parallel air gap set to a nominal spacing of 0·01in (0·25mm) between each line connection and earth

The type-16 protector is available in three ranges of d.c. striking voltage: 150V–350V (type-16A), 300V–500V (type-16B), and 600V–900V (type-16C). A coating of heat-resistant enamel between electrodes gives added protection against dust and moisture deposits and is also coloured to indicate the striking voltage range.

As with most three-electrode protectors, the initial striking voltage and speed of operation are better than could be expected with separate two-electrode units. Although it is not practicable to control these characteristics so that they are exactly the same in each gap when tested independently, the electrode arrangement in the new protector ensures a near approach to simultaneous operation when excess voltages, balanced or unbalanced, appear on both line wires.

Thus, as soon as one gap strikes, the ionisation of the gas results in the striking voltage needed in the other gaps being much reduced with almost instantaneous operation if that striking voltage is present. In this way, in addition to excess potential on either line wire being discharged to earth, any large potential differences between the line wires will tend to be reduced much more effectively than with a separate two-electrode device being connected across them.

Operating delay is less than one microsecond when 1500V, d.c. with a rise-time of less than 0·1 microsecond is applied. The protector will withstand without damage ten one-second applications of 20A, a.c. every three minutes on any one section. It will also withstand at least 150mA, a.c. for three hours without damage. Insulation resistance measured at 85V is far greater than 1000 megohms between any two electrodes and high insulation is maintained under high humidity conditions. The arc voltage is of the order of only 20V, so the protector can handle heavy surge currents effectively. On any gap it will withstand many hundreds of 100-Joule discharges where peak current is greater than 10,000A.

Mountings for the type-16 protector are available in unit and strip form, and as cable terminals or pot-head insulators; a specimen is illustrated.

[Reply Card No. E2551]

Tractor-Mounted Air Compressors

AIR compressors of a new series offered by Atlas Copco (Gt. Britain), Ltd., Maylands Avenue, Hemel Hempstead, Herts., depend upon a normal agricultural tractor to carry and drive them; hence they can deliver compressed air in remote and inaccessible places for forestry, civil engineering, or farming activities. The compressor is a reciprocating, two-cylinder, two-stage machine with an intercooler; the air receiver forms a surrounding frame on which the unit can be set down. Adjustable mounting points allow the set to be connected to the tractor's three-point linkage, and a splined propeller shaft connects to the power take-off.

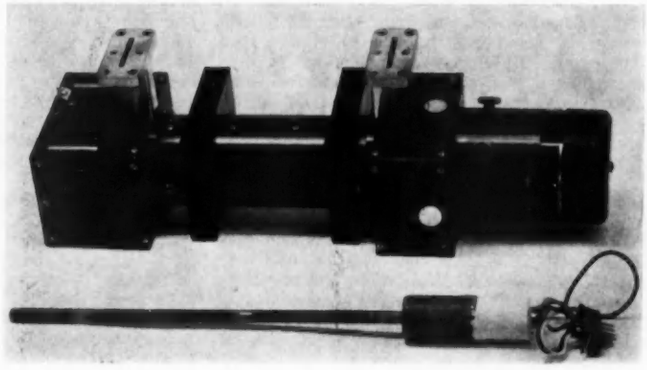
Two main models of compressor are available, both rated to deliver at 100 lb per square inch. The "125NT" delivers 125 cubic feet per minute f.a.d., running at 1800 r.p.m., with inputs of 540 r.p.m. or 720 r.p.m. to choice; it weighs 860 lb. The "IT" weighs 700 lb; the "100" version delivers 100 cubic feet per minute at 1960 r.p.m. with the above-mentioned choice of inputs, while the "80" delivers 78 cubic feet per minute at 1450 r.p.m. compressor speed and 540 r.p.m. input.

[Reply Card No. E2552]

A "100IT" compressor traversing rough ground on a Fordson "Power Major" tractor

Travelling Wave Tube for 6000 Mc/s

WE illustrate a 15W travelling wave tube power amplifier for the 5925–6425 Mc/s band which is now in production by the M–O Valve Company, Ltd., Hammersmith, a subsidiary of The General Electric Company, Ltd., and is being used in the Carlisle–Kirk o'Shotts and Dundee–Harrogate microwave links for which the G.E.C. has supplied and installed the radio equipment. The tube, TWC5, has periodic focusing of the electron beam within the signal-carrying helix by means of a sequence of permanent magnets. While this results in reduced weight and lower stray fields compared with electromagnetic focusing, it demands high precision in locating the tube inside the magnet system. The design of this amplifier, however, enables the user to replace tubes without difficulty in correct relation to the magnets. Provision for final trimming is made by means of the screws and plugs seen at the right-hand end of the permanent magnet mount in the accompanying illustration. Next to these is the input waveguide, and at the opposite end of the mount the output waveguide. Beyond this will be noted the cooling fins for the collector on which the electron beam impinges at the end of the helix.



Travelling wave tube with periodic permanent magnet focusing

Other essential features in a tube of this kind are maintenance of uniform pitch in winding the helix, and concentricity of the inner and outer walls of the glass tube in which the helix is enclosed. Strict production control of metal and glass components is therefore exercised. The complete tube assembly is seen withdrawn from the magnet system in the foreground of the illustration. While developed specially for multi-channel telecommunications systems operating in the range of frequencies mentioned above, the permissible bandwidth coverage of the TWC5 tube is considerably greater. Development of the tube took place at the Hirst Research Centre of the G.E.C. (see our January 27 issue).

[Reply Card No. E2553]

SHORTER REPORTS *(Continued)*

Repeater Switch for Use with 11kV 150MVA Fuse Switches

LAST April it was announced that the type-D expulsion fuse-switch made by Johnson and Phillips, Ltd., Charlton, London, S.E.7, for the protection of overhead line distribution schemes, had been uprated to 150MVA. This higher rating was achieved with only minor modifications to the original design, now twenty-five years old. Moreover the operation of the uprated fuse-switch was much more precise at all current values and particularly at the low currents of 200A to 300A which had previously proved critical. Certificates have since been issued by the C.E.S.I. Laboratories in Milan in accordance with B.S. 2692 : 1956 covering operations at all current values up to 8000A at 11kV.

The manufacturer has now introduced a repeater unit for use with the new fuse-switches which has been fully tested for the same ratings. The type-D repeater is designed to provide automatic restoration of overhead line supplies after momentary faults have cleared, by bringing a second expulsion fuse-switch into the circuit if the first fuse has blown. It is based on the general experience that most faults on overhead lines are transient and that the power arc resulting from the flow of fault current usually destroys the cause of the fault whilst the arc itself is extinguished by the opening of the fuse-switch. By the use of a repeater the circuit can be restored automatically through a second fuse.

The repeater unit is mounted on one of two adjacent type-D fuse-switches, both of which are fitted with horn type contacts. It consists of a self-aligning contact bar carried at the end of a spring-actuated operating arm. Normally, as shown in the top illustration, this arm is held in the open position by a release catch and depends on the weight and force of the falling fuse-carrier to cause it to close. When a fault occurs the fuse-carrier of the first fuse-switch, in falling down to its open position (lower illustration), strikes the release catch of the repeater operating arm, thereby permitting the contact bar to be thrust upwards and bridge the horn contacts of the two fuse-switches. The supply is thus restored through the second fuse-switch. If the fault is not cleared the circuit will again be opened by the second fuse-switch.

To reset the combination in its original condition the only action required, after replacing the blown fuses, is to close the first fuse-switch by means of the operating pole and, with the same pole, to open the repeater unit by pulling down the operating arm until it is held by the release catch.

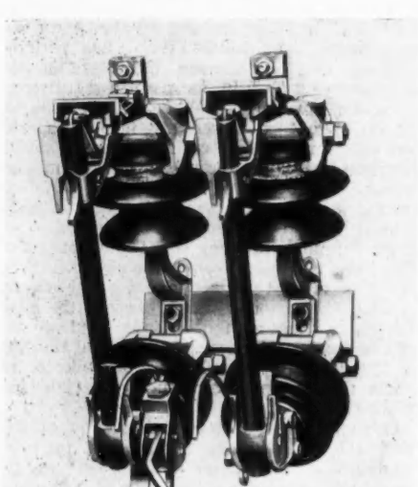
Three sets, each comprising a repeater and two fuse-switches are required on three-phase systems ; for single-phase systems two sets are usually required. To reclose the circuit more than once, two reclosures can be provided by using three fuse-switches per phase, or three reclosures by using four per phase.

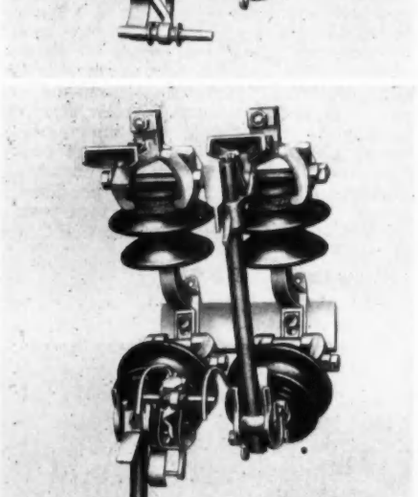
The use of the repeater not only reduces the inconvenience to consumers by giving them immediate restoration of supply without waiting for a linesman to visit the site and renew the fuse but also eliminates much of the linesman's emergency work. The affected fuses can be renewed later during normal inspection tours.

The new repeater unit was tested at the C.E.S.I. Laboratories using a single-phase circuit with a full 11kV line-to-line recovery voltage. British Standard 2692 : 1956 for expulsion fuse-switches does not cover repeater units but the tests are stated to have proved that the type-D fuse-switch fitted with a repeater unit is capable of meeting the requirements set out in the Standard, i.e. of satisfactorily operating under fault conditions not exceeding rated capacity, without dangerous scattering of hot metal or other substances, and without breakdown or damage to associated equipment or significant electrical leakage to earth or between poles.

The maker states that after operation, the mechanical parts and supporting isolators were essentially in the same condition as before the test and, after renewal of the element, the fuse-switch and the repeater were capable of carrying the rated current at rated voltage and operating at a fusing current up to breaking capacity rating.

[Reply Card No. E2561]





(Above) Normal condition ; fuse switches closed and repeater switch open
(Below) Fault condition ; left-hand fuse carrier open and repeater switch closed to restore the supply through the right-hand fuse switch

Conduit System for Control Desk

WE illustrate a teleciné control desk at the B.B.C. Television Centre, Wood Lane, which has been equipped with flexible conduit for carrying groups of conductors requiring rapid connection to any one of several outputs. In this instance the desk enables any one of eighteen teleciné outputs to be routed to any of a similar number of duplexers for switching the teleciné machines sequentially to the output lines. The conduit is the "Conflex" electrical conduit system manufactured by Superflexit, Ltd., Slough.

Individual conductors have been used throughout, and their lay inside the conduit received special attention to avoid cross-talk and interference between circuits, since each wired assembly carries vision, sound, talk-back, cueing and control circuits. The wiring includes coaxials quads, screened and unscreened conductors. Conduit assemblies are screened continuously up to the connectors themselves. An advantage of the system over conventional cabling is that if changes of equipment design require a different form of conductor for a particular circuit, the new conductor can be inserted in the conduit without replacing the others in the same assembly. The construction of the conduit also withstands frequent flexing better than cabling. A complete assembly with its connectors, can be removed by undoing one lock-nut at each end.

"Conflex" conduit was introduced primarily for airborne installations, but the facility for housing any combination of conductors with individual or overall screening has proved of general use because of the flexibility it allows to the designer. The conduit in this installation is P.V.C. wire reinforced convoluted, comprising a thin wall conduit with stainless steel internal helix and P.V.C. coated wire armouring externally. Other varieties available are P.T.F.E. convoluted, comprising a thin wall extrusion suitable for a continuous rating of —70 deg. to 240 deg. Cent., and P.V.C. convoluted, a thin wall extrusion recommended for a maximum temperature of 70 deg. Cent.

[Reply Card No. E2562]

Teleciné control desk at B.B.C. Television Centre, Wood Lane, with circuits assembled in flexible conduit

INDUSTRIAL NEWS

Coal Prospects

On Wednesday, February 8, the Rt. Hon. Alfred Robens, chairman of the National Coal Board, addressed the National Industrial Fuel Efficiency Service Conference in Glasgow. Mr. Robens said that he welcomed the opportunity of reviewing the prospects of the coal industry, and especially its prospects in Scotland. He reminded the Conference that about one person in ten in Scotland depended directly upon the coal industry for a livelihood, and that one ton of coal in every ten produced in Britain was furnished by Scotland. The Board looked to the Scottish coalfield, he added, to maintain roughly this contribution in future, some 18,000,000 to 20,000,000 tons out of the total of 200 million to 215 million tons envisaged in the Board's plan for 1965.

The chairman went on to outline some of the grave risks involved in subjecting the coal industry to rapid changes in demand. The coal industry carried a heavy burden of fixed charges which scarcely varied with output, he said, and we were now at the stage where the less coal we produced, the dearer each ton became. A large part of the decline in coal consumption between 1956 and 1959, he suggested, was attributable to intense competition from oil. The oil industry was confident that its long term problem would be scarcity, not surplus as at present. We were also assured by leading oil men, he added, that fuel prices were unduly low. It would surely be unwise in these circumstances, Mr. Robens said, to jettison coal-producing capacity when we knew how difficult, uncertain, and expensive re-expansion would be.

Mr. Robens went on to say that the effects of the oil industry's operations on the United Kingdom's balance of payments were not revealed to the public. He could not affirm categorically, he said, that the operations of the oil industry in 1959 or 1960 resulted in a very large net loss to Britain as far as overseas payments were concerned ; but that is what all the available information suggested. What was indisputable, he continued, was that every additional ton of imported oil added to the burden of our overseas payments, for it was certain that during recent years the rate of increase in our oil imports and in our payments for them had substantially exceeded the rate of increase in oil companies' overseas sales and earnings.

Iron and Steel

The latest figures issued by the Iron and Steel Board indicate that production of crude steel during January, 1961, rose to an average of 478,400 tons a week from the December rate of 451,100 tons a week. The average rate in January was reduced to the extent of about 15,000 tons a week by the New Year holiday, and if allowance is made for this loss, the Board says, production in January approaches the average of 501,200 tons a week reached during October and November.

The recently-announced reductions in the number of shifts worked at some of the continuous mills producing sheet and tinplate had little effect during January on the production of crude steel. Some of the steel output associated with the continuous sheet and tinplate mills has been used in recent weeks to increase the stocks of ingots and semi-finished steel. The Board reports that the rate of output at works producing other products also remained high.

The early results of the census of stocks of steel held by users and merchants at the end of December, 1960, suggests that stocks rose by about 6 per cent, or 240,000 tons of finished steel, during the fourth quarter of the year. This is somewhat greater, the Board points out, than the rise of 200,000 tons in the third quarter. Stocks of sheet continued to rise, although not so rapidly as in earlier quarters. During the year 1960, the Board says, stocks of sheet are estimated to have risen by 370,000 tons or nearly 80 per cent compared with a rise of 530,000 tons or 20 per cent. for all other types of finished steel. The preliminary stock figures enable the usage of steel in the home market for the fourth quarter to be assessed at 3,810,000 tons, a rise of 10 per cent over the usage in the fourth quarter of 1959.

The group of light re-rolled products, including wire rod, ferro-concrete bars and light sections and bars, together with the flat rolled products, strip, sheet and tinplate, all show rates of delivery well maintained through 1960, the Board says, and considerably above the levels reached in 1957, the previous period when activity was high throughout the steel industry. Light re-rolled products and thin flat rolled products now represent about 55 per cent of the total gross deliveries of finished steel, compared with 49 per cent in 1957 and 45 per cent before the war. Deliveries of plate and heavy sections have been on an upward trend through 1960 and towards the end of the year were showing a gain above the levels reached during 1957. Rails and colliery arches, the Board adds, were the only main products with rates of delivery below the 1957 figures.

Industrial Trends

The report on the tenth inquiry made by the Federation of British Industries into industrial trends in this country suggests that a continuation of the trend which is reported this time would produce a disturbing situation. Falling orders coupled with rising stocks could lead, the Federation says, to cut-backs in production and employment, while rising costs would jeopardise our export competitiveness. But though the general mood is of lessening optimism, the Federation adds, the detailed expectations give some hope that this trend may be halted.

The report is based on information provided by 752 firms selected to give a sample of manufacturing industry which is representative both in activity and in size, and relates the situation at the end of January to that four months previously. The most significant feature is the change in the order position, the Federation says. In the two previous inquiries there had been some falling off in the balance of ups over downs from the high level reported a year ago. This time there is a slight downward balance. There is also a rather more significant fall in the length of order books, and the report shows that the shortage of orders has now become the most important limiting factor to expansion. Output is reported to have risen on balance by the smallest margin over the past year. The apparent inconsistency with the official statistics, the Federation says, is probably explained by the fact that significant reductions of output have been concentrated in comparatively few firms. For the first time over the past year, the report states, labour is on balance easier to recruit.

In this situation, the Federation points out, it is not surprising that for the first time in the past year an upward movement in stocks of finished goods is reported. Raw material stocks have continued to rise, contrary to the expectations last October.

The decline in orders applies to consumption goods in the home market. Export orders on balance show no change, while orders for capital equipment are still rising. This latter trend is confirmed by the reported continued rise in intended investment in plant and equipment : this trend continues despite the apparent weakening in order books.

The combination of higher hourly wages and the rising price of some materials and fuels coupled with a steadier level of output has led to the biggest rise in costs per unit, the Federation says, which has been recorded since the inquiries began three years ago.

Trade with China

According to the January issue of the *China Trade and Economic Newsletter*, Great Britain's trade with China last year reached the record level of £57,000,000, compared with a total trade of £7,500,000 in 1952 and £27,000,000 in 1957. During 1960 China bought from Great Britain nearly £8,000,000 worth of copper wire rod, nearly £6,000,000 worth of iron and steel, and electric and other machinery valued at over £3,750,000. The *Newsletter* quotes Chinese estimates of requirements to fulfil its agricultural programme, including several million tractors against a present tractor force of about 100,000 and an annual domestic production of 20,000. It states that tens of millions of tons of fertiliser are required annually, whereas output in 1959 was only about 1,300,000 tons. *Newsletter* goes on to suggest that 1961 opens with many opportunities " for further business in tractors and agricultural tools, fertiliser and insecticides as well as in bulk cargoes of flour, grains and various other agricultural products recently bought by China in Commonwealth and other free markets."

When shipments under contracts placed within the last few weeks have been completed, Britain will have supplied tractors to the value of £2,500,000 to China since 1956.

PERSONAL AND BUSINESS

Appointments

SQUARE D, Ltd., has announced the appointment of Mr. G. K. Robinson as its Newcastle branch manager.

MR. B. L. BARDELL and MR. N. H. OLLEY have been appointed joint technical directors of M.T.E. Control Gear, Ltd.

MR. E. J. INGRAM has been appointed managing director of Bengeworth Steels, Ltd., and Coltrate Metal Treatments, Ltd.

AITON AND CO., Ltd., states that Mr. R. H. Boissier has been appointed London area manager in place of Mr. G. R. H. Trollope, who has resigned.

THE GLOBE PNEUMATIC ENGINEERING COMPANY, Ltd., announces the appointment of Mr. Colin Broome as the company's representative in Yorkshire.

MR. COLIN G. KNELLER has been appointed advertising and sales promotion manager of the British divisions of the Yale and Towne Manufacturing Company.

PETTERS, Ltd., a member of Hawker Siddeley Industries, has announced the appointment of Mr. R. G. M. Cawson as works manager at its Staines factory.

MR. L. J. RENNOCKS has been appointed works manager of the Dunlop sports rackets factory at Waltham Abbey, Essex, on the retirement of Mr. H. Hatfield-Smith.

MR. C. HOLMES-WALKER has been appointed eastern divisional manager of the Power Petroleum Company, Ltd., in succession to Mr. H. R. C. Rides who retired in January.

THE COLLEGE OF AERONAUTICS has announced the appointment of Dr. A. H. Lefebvre, A.M.I.Mech.E., to the chair of aircraft propulsion, in succession to Professor A. G. Smith.

MR. M. STIPELMAN, M.I.Mech.E., general manager of Associated British Machine Tool Makers, Ltd., retired on December 31, 1960. He has been succeeded by Mr. C. E. Middlemiss.

STEIN ATKINSON VICKERS HYDRAULICS, Ltd., has appointed Mr. J. R. Sinclair, A.M.I.Mech.E., as a senior sales engineer to represent its interests in the South Wales and Gloucester areas.

VACUUM INDUSTRIAL APPLICATIONS, Ltd., Wishaw, has announced the appointment of Mr. Lionel Swindells as northern representative. His address is 22, Lynton Avenue, Rochdale, Lancs.

CAPTAIN I. R. FINLAYSON has been appointed superintendent in charge of the submarine branch of the Post Office engineering department in succession to Captain W. H. Leech, who has retired.

MR. JAMES RITCHIE has been appointed financial director of Holman Brothers, Ltd. Two associate directors, Mr. J. L. Ritchie, sales director, and Mr. J. M. Williams, London director, have also been appointed directors.

MR. K. R. SIMMONDS, A.M.I.E.E., has been appointed managing director of International Rectifier Company (Great Britain), Ltd., a company owned jointly by Metal Industries, Ltd., and the International Rectifier Corporation of Los Angeles.

MR. J. R. ROWLANDS, a director of Henry Simon (Holdings), Ltd., and managing director of Simon Handling Engineers, Ltd., has been appointed a director of Simon-Carves, Ltd. Mr. G. P. Bridges has retired from the board of Simon-Carves, Ltd.

THE SOUTH WESTERN ELECTRICITY BOARD announces that Mr. R. F. Richardson, M.I.E.E., has been appointed a member of the board for a period of three years from May 1. Alderman S. H. Payne has been re-appointed a member of the Board for a further period of two years from April 1.

THE GENERAL ELECTRIC COMPANY, Ltd., announces that Mr. T. B. O. Kerr has been appointed deputy managing director. It also announces that Mr. E. H. Davison has been appointed financial director of the company. Courtaulds, Ltd., has agreed to release him from his position as treasurer so that he can take up his new duties on March 1, 1961.

HAWKER SIDDELEY BRUSH INTERNATIONAL, Ltd., the company responsible for all overseas sales by the Hawker Siddeley Industries organisation, announces that Mr. H. M. Loader, M.I.E.E., has been appointed area director in Asia and the Far East, and Mr. G. R. P. Willan, A.M.I.E.E., A.M.I. Mech.E., who has been the executive director based on Beirut, fills the position previously held by Mr. Loader as area director for Africa and the Middle East. Both Mr. Loader and Mr. Willan are based in London.

Business Announcements

ELEVADORES ATLAS S.A., Sao Paulo, announces that its name has been changed to Industrias Villares S.A.

RENAULT, Ltd., has opened a new parts depot, with a floor area of 33,000 square feet, at Western Avenue, London, W.3.

HIGH DUTY ALLOYS, Ltd., Slough, Bucks, states that the telephone number of its extrusion division has been changed to Workington 2581-6.

H. WILLIAMS AND SON, Ltd., Lark Works, St. Albans, Herts, has been appointed sole agent for the United Kingdom for metal cutting bandsaws made by Hakanssons of Amal, Sweden.

POROUS PLASTICS, Ltd., has appointed two overseas agents, the Guardian Chemical and Equipment Company, Ltd., P.O. Box 392, Station "O," Montreal 9, P.Q., Canada, and Industrial Composizioni Stampate, via Guastalla 2, Milan (241), Italy.

MR. J. L. RITCHIE, sales director of the Holman Group, left London by air on January 31 for Mexico City, on the first leg of a tour of South America. Mr. Ritchie will visit eight countries for meetings with Holman agents and technical representatives.

DE HAVILLAND AIRCRAFT COMPANY OF SOUTH AFRICA has now become Hawker de Havilland (Pty.), Ltd., following the merger of the de Havilland Companies with the Hawker Siddeley Group. Mr. J. Davison has become managing director of the new company.

POLYPENCO, Ltd., Tewin Road, Welwyn Garden City, has announced the formation of a new subsidiairy company, Polypenco (France) S.A.R.L., 91, Rue de Billancourt, Boulogne (Seine), to market the range of engineering plastics manufactured at the Welwyn Garden City plant.

MR. J. E. C. BAILEY, managing director of Baird and Tatlock (London), Ltd., Hopkin and Williams, Ltd., and W. B. Nicolson (Scientific Instruments), Ltd., is leaving the United Kingdom on February 5, for a tour of the companies' branches and agents in Africa. He returns to this country on March 4.

EDGAR ALLEN AND CO., Ltd., Sheffield, has established an Australian subsidiary, Edgar Allen and Co. (Aust.), Pty., with headquarters in Melbourne. The Australian subsidiary has taken over Edgar Allen Noyes Pty., Ltd., which was previously operated as a partnership by Edgar Allen and Co., and Noyes Brothers of Melbourne.

S. F. MOKES AND CO., Ltd., of Walsall, a firm specialising in precision engineering, recently moved to a new factory in Rolling Mill Street, Walsall. The new factory provides for an increase in plant and the eventual doubling of the present number of employees. Recently Mr. Leonard Day was made works manager of this company.

THE FAIREY COMPANY, Ltd., announces that its subsidiary Siebe, Gorman and Co., Ltd., has made an offer for the whole of the issued share capital of C. E. Heinke and Co., Ltd. The offer has been accepted by the directors of C. B. Heinke and Co., Ltd., in respect of their own holdings and they are recommending its acceptance to the remaining shareholders.

THE WELLMAN SMITH OWEN ENGINEERING CORPORATION, Ltd., Parnell House, Wilton Road, London, S.W.1, and THE INCANDESCENT HEAT COMPANY, Ltd., announce that agreement has been reached on a basis for Incandescent and its subsidiaries to join the Wellman Group. Wellman will offer to purchase the whole of the issued share capital of Incandescent.

BRITISH SPACE DEVELOPMENT COMPANY, a new joint organisation, has been formed to bring together a representative cross-section of that part of industry which is interested in the development and exploitation of space for commercial purposes. The company has an initial capital of £20,000. Its first members will be Associated Electrical Industries, Associated Television, British Insulated Callender's Cables, Decca Radar, de Havilland, Pye, the Rank Organisation, and Rolls-Royce.

HERBERT MORRIS, Ltd., Loughborough, and BUTTERS BROTHERS AND CO., Ltd., Glasgow, have announced the formation of a new company to foster the development, design and marketing of engineering equipment of interest to both firms. The new company, Morris and Butters, Ltd., will operate from the office of Butters Brothers and Co., Ltd., at Hillingdon, Middlesex. Mr. Benjamin Butters has been appointed chairman of the new company, and Mr. Alex. Sykes managing director.

BROADWELL ENGINEERING, Ltd., has opened new offices and works at Dudley Road East, Tipton, Staffs, telephone, Broadwell 3102 and 1049.

I.C.I. (HEAVY ORGANIC CHEMICALS), Ltd., a wholly-owned subsidiary of Imperial Chemical Industries, Ltd., went into voluntary liquidation as from December 30, 1960, and its assets and liabilities have been transferred to the parent company. The business of the subsidiary company is being continued as a going concern by Imperial Chemical Industries, Ltd., and is now known as the heavy organic chemicals division of that company. The headquarters of the division will remain at Organic House, Billingham, County Durham.

Contracts

DURAPIPE AND FITTINGS, Ltd., has received a contract from the Admiralty for the supply of "Durapipe" for the prewetting installations in four Guided Weapon Destroyers now being built.

HANDLEY PAGE, Ltd., has received jointly from Maritime Central Airways of Charlottetown, Prince Edward Island, and Nordair, Ltd., of Montreal, an order for two Series 200 "Dart Herald" airliners with an option on a further six. The machines will have accommodation for fifty passengers or, in all-freight configurations, for 6 tons of cargo; Maritime Central operate regularly in the Arctic supplying the Pine Tree and DEW Line radar stations.

THE YORKSHIRE HEENEBIQUE CONTRACTING COMPANY, Ltd., has been awarded a contract for building a new bridge over the River Derwent at Kexby, about 5 miles east of York on the York-Hull Trunk Road, A.1079, and nearly 700 yards of approach roads. The tender was £111,293, and work should be completed by the autumn of 1962. The new bridge will have a single reinforced concrete arch with a span of 110ft. The abutments will also be of reinforced concrete, each with counterbalanced boxes containing mass concrete filling, and hinged rocker bearings resting on piled foundations. The scheme has been designed for the Minister of Transport by Messrs. L. G. Mouchel and Partners.

BLACKBURN ELECTRONICS, Ltd., has received orders for data logging equipment for export to Belgium and Iran. The Belgian order was placed by the Société de Traction et d'Electricité, consulting engineers for a power station being built at Mol, near Brussels, where the equipment is required for checking 130 different readings of temperatures, pressures, and other conditions. The second order was placed with the company by Rendel, Palmer and Tritton, consulting civil engineers, in connection with an oil pumping station project of the National Iranian Oil Company at Abadan. This equipment is for automatic monitoring of the temperatures of pump motors and for giving alarms when temperatures exceed preset limits.

Award

THE COUNCIL OF THE INSTITUTE OF METALS announces the following awards for 1961: The Institute of Metals (Platinum) Medal, to Major C. J. P. Ball, F.R.Ae.S., F.Inst.Met., chairman of Magnesium Elektron, Ltd., in recognition of his outstanding services to the non-ferrous metal industries and, in particular, to the magnesium industry; the Rosenhain Medal to Dr. P. B. Hirsch of the Cavendish Laboratory, Cambridge, in recognition of his outstanding contributions in the fields of physical metallurgy and metal physics.

Deaths

WE record with regret the death of Mr. R. Y. Sanders, F.S.S., F.R.Econ.S., F.R.Met.Soc., which took place on February 3. Mr. Sanders retired from the post of deputy commercial and development adviser to the Electricity Council in September, 1959, but had continued to serve the Council in a consultative capacity. He was one of the first officers appointed to the headquarters staff of the Central Electricity Board on its establishment in 1927, serving successfully as statistical officer, development officer and from 1943 as head of the development and economic section. He was also secretary of the Board's National Consultative Committee from 1944 to 1948. In 1948 he became deputy commercial manager to the British Electricity Authority and later became deputy chief commercial officer.

Australian-American Experiments on the Theory of Rain-Making

By OUR AUSTRALIAN CORRESPONDENT

THE Commonwealth Scientific and Industrial Research Organization has, since 1947, been carrying out intensive investigations into phenomena in nature associated with rainfall. These experiments have included "seeding" of suitable clouds with silver iodide discharged from aircraft, and results over test areas have supported the belief that rainfall may be accelerated or induced using this method.

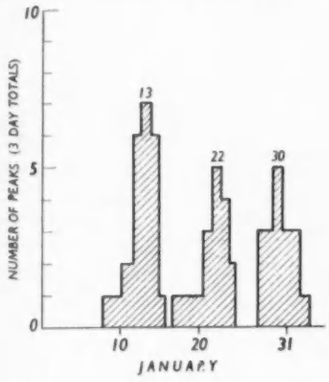


Fig. 1—Histogram of the dates in January on which the concentration of freezing nuclei was observed to be high in the three years 1954, 1955 and 1956

It has been established that unless a cloud has a certain moisture content no amount of artificial seeding will cause rain to form, but the traditional working tool of the meteorologist, the synoptic chart, shows only the barometric pressure distribution over the Earth's surface at any one time. Unless the parameters used by the meteorologist include some method of measuring the moisture content of clouds or forecasting when the moisture content is likely to favour rain, the question of whether rain will fall at a specified time and place is still answered by using more intuition and past experience than the physicist likes to employ.

Cloud physicists have established that the number of freezing nuclei, particles on which ice crystals can grow from the vapour phase, or which will induce a water droplet to freeze on contact in the atmosphere, has a direct bearing on the formation of rain. By measuring the density of these nuclei from aircraft or balloons, or at sites free from terrestrial or industrial dust interference, it has been found that while concentrations may be consistent over large areas, or for several hours, it may change in the ratios of several hundred to one over succeeding days.

From measurements of the freezing nuclei counts taken over a period at several widely spaced points on the globe, indications are that sudden changes occur almost simultaneously at different places, and seem to recur on approximately the same dates each year. Fig. 1 is a histogram showing the dates on which freezing nuclei counts were high in January for the three years 1954, 1955 and 1956. These dates corresponded closely for places as widespread as the United States, South Africa and New Zealand, and the dates have a close correlation with peak falls of rain, as shown in Fig. 2, despite widely differing climatic regimes, and the fact that winter and summer conditions are prevailing simultaneously in the opposite hemispheres.

The implications of these observations on the possibility of inducing rain for specific purposes over selected areas are obvious, and the efforts of the Radio Physics Division under Dr. E. G. Bowen have been directed towards identifying the source of these freezing nuclei, and establishing its reliability. Dr. Bowen's belief, from the simultaneity of the effects over the globe, that the source is connected with some extra-terrestrial phenomenon, was the subject of a joint U.S.A.F.-C.S.I.R.O. experiment in November-December, 1960.

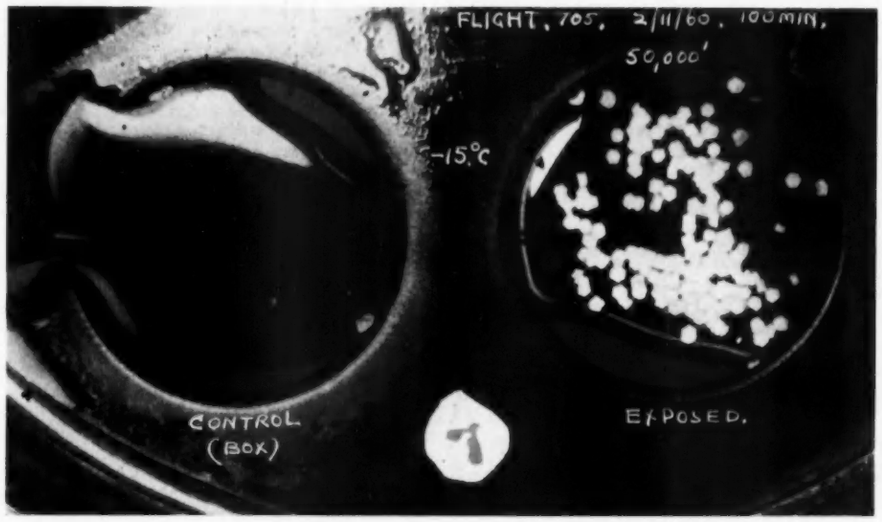


Fig. 3—Crystal formation on freezing nuclei after flight at 50,000ft in "U-2"

Over the period May to August, 1959, R.A.A.F. "Canberra" aircraft had been used to measure freezing nuclei concentrations up to heights of 44,000ft, and a significant conclusion was that, as concentrations near the tropopause were of the order of ten times the ground-level values, the nuclei do not all originate at the Earth's surface.

With the arrival of Lockheed "U-2" high-altitude aircraft in Australia in November 1960, a unique opportunity was provided for extending the previous experiments to measurements at 60,000ft. The aircraft were fitted with pairs of dust-collecting filters, one of which was shielded from the airstream as a control, while the other was exposed to the airstream at appropriate altitudes. Following each flight the filters were reduced in temperature to —15 deg. Cent., at which temperature ice crystals would form on any freezing nuclei trapped by the filters.

Fig. 3 is a photograph of the resulting crystal formation following a flight at 50,000ft on November 2, 1960, and other flights have shown that considerable numbers of particles exist above 60,000ft, thus lending support to the extra-terrestrial theory. It is hoped to make measurements up to 100,000ft by the use of balloons and sounding rockets to test the theory further.

Dr. Bowen has suggested that—as the rainfall peaks corresponding to the peak freezing nuclei concentration of January are preceded at thirty-day intervals by prominent meteor showers, (the Geminids on December 13, the Ursids on December 22 and the Quadrantids on January 3)—that the streams of meteoritic dust through which the Earth passes regularly may be the source of the freezing nuclei. The smaller, low energy particles are not burned up on entering the atmosphere and sink slowly into the troposphere over a period of thirty to forty days from first reaching the atmosphere.

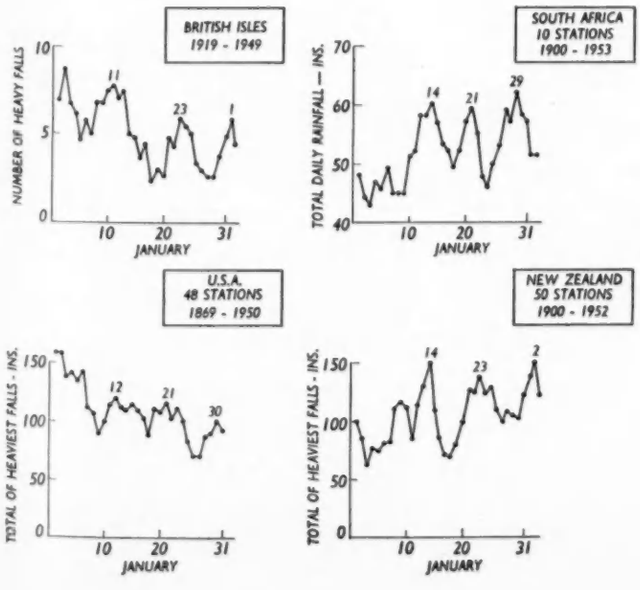


Fig. 2—The January rainfall of four countries in widely separated parts of the world

Indian Nuclear Power Plant

By OUR INDIAN CORRESPONDENT

IN October the Department of Atomic Energy issued a notification inviting global tenders for India's first nuclear power station, to be built near Tarapur, some 62 miles north of Bombay. The inquiry specification outlining in detail the requirements of the station was issued soon afterwards. The tenderers have been given about 7½ months' time to formulate and submit their tenders. The power station is designed to produce 300MW of electric power and will consist of two nuclear reactors of equal capacity. The specification has stressed the need for keeping the foreign exchange component to the minimum. The tenderers are to employ to the greatest possible extent indigenous materials, locally fabricated equipment and Indian personnel. The Tarapur plant is reckoned to cost Rs.51 crores and will take five years for completion. It will use natural uranium as fuel; to begin with it will require 350 tons of fuel to be replenished by an additional supply of 120 tons annually.

A delegation on behalf of the Atomic Energy Commission left Bombay on October 18 for Europe, Canada and America to visit atomic power stations there with a view to studying the latest technical progress in designs and the management problems involved in the construction of such projects. It was headed by Mr. M. N. Chakravarti, Project Administrator, Tarapur Atomic Power Project, and comprised Dr. M. R. Srinivasan and Mr. Maheshwar Dayal, engineers of the Tarapur Project. The delegation was joined in Paris by Dr. Homi J. Bhabha, chairman of the Atomic Energy Commission for part of the tour.

The choice of Tarapur for siting the nuclear power plant was preceded by a preliminary hydrographic survey. The search for a suitable location was conditioned by three factors : the suitability of terrain for a sound base, abundance of water and proximity to the areas to be served. Tarapur's rocky coastline provides an ideal foundation for the water-coolant type of reactors to be built at a location where the tide ebbs and flows. The Arabian Sea furnishes the ample water supply necessary for this type of reactor. Geographically Tarapur is well situated to serve the power needs of both Gujarat and Maharashtra States. It is proposed to lay a dam across either the Surya or the Susari River for the supply of fresh water to the power-house. Work on the preparation of the 50-acre site and on a road to link Bhoisar, the nearest railhead on the Western Railway system, has started.

For a comparison between coal-burning and nuclear power stations, leaving aside any advantages of siting, the three main factors are capital cost, fuel cost and load factor. For a station of 300MW to 360MW capacity in the U.K. a coal station cost in 1956-58 was £60 per kilowatt (s.o.) and a nuclear station £120 per kilowatt (s.o.). The new 550MW station at Oldbury-on-Severn will probably be the first U.K. nuclear power plant to have a capital cost of less than £100 per kilowatt of electricity sent out, compared to £160 per kilowatt for the Berkeley Station 4 to 5 miles away and £110 per kilowatt for the Dungeness (Kent) Station. This higher cost of the atomic plant is reflected in the annual charges in the unit cost. To this should be added interest on the value of the fuel charge contained in the reactor. The cost of nuclear fuel per kilowatt-hour on the basis of closely estimated figures is roughly half that of an average coal-fired station. The cost of electricity generated by a nuclear station is much more sensitive to the load factor than that from coal-fired stations on account of the high proportion of capital charges. At 80 per cent load factor the generating cost was estimated in 1957-58 at 0·77d. for coal and 0·61d. for nuclear generation. Also, a percentage increase in the cost of coal has a greater effect on the total cost of generation than has the variation in the cost of uranium in the performance of a nuclear plant.

It has been pointed out that the generating cost of a unit of electricity at Tarapur would be in the region of 3·5nP. If a thermal station were to be located at Tarapur, a region far removed from coal producing centres, the generating cost per unit of thermal power would be about the same. The capital outlay of Rs.51 crores for generating 300 MW of power here would, of course, be much higher than that of a thermal power station of the same capacity. A thermal station at Tarapur would cost around Rs.32 crores, taking Rs.1050 as the capital investment on 1kW of power. But the location of a thermal power plant here would present a transport problem of considerable dimensions. Assuming it to be of the same size as the nuclear one, the transport of 1,200,000 tons of coal from distant collieries in the north and north-east to the plant site would have to be arranged : it means that 175 wagon loads of coal would have to be on the move day after day to Tarapur. If the capital outlay and the cost of transport were taken into account the gap between capital investment on nuclear and thermal power would be narrowed by a margin of some Rs.12 crores. If these calculations are accepted the nuclear power station at Tarapur would cost only Rs.7 crores more than a thermal station of the same size and on the same site. Additionally the nuclear power station would relieve the railways of a considerable transport strain.

In the near future the use of coal in India would more and more be confined to heavy industries, chemical works and industrial processes. Where it is economical to employ the raised steam for limited power generation by elevating its temperature and pressure before being used for process work, pass-out or back-pressure sets should certainly be considered. The burden of coal transport on rail tracks and wagons would be reduced. A sound foundation would be laid for zonal 220kV to 110kV grid from Gujarat in the north to Mysore in the south. There are reserve generating plants at strategic points in this grid network which will enable the authorities to get over the chronic power shortage throughout the zone, provide for industrial expansion or new development, and carry out main-line electrification from Bombay to Surat on the Western Railway, from Igatpuri to Bhusaval and from Poona to Dhond on the Central Railway. Thus, quite apart from the suitability of the site from the atomic angle, the Government of India's decision to locate the 300MW station at Tarapur to serve as a load station between Gujarat and Maharashtra base has much to commend it.

The north region in the western zone has no potentials to make hydro-electric projects attractive from an economic standpoint compared with the Tarapur nuclear power station of 300MW to 350MW capacity. The capital cost per kilowatt of such water-power stations would be higher than that of Koyna, which is placed at Rs.1800 per kilowatt. This figure is much higher than that of the proposed atomic power station. Moreover, in the case of hydro-electric stations the sites are generally far removed from load centres and when comparing capital cost figures an additional charge must be allowed for transmission investment. The nuclear station running day and night makes it ideal for base load duty on an interconnected system. The higher the load factor the lower the cost component of the total outlay on electricity.

With a 220kV to 110kV grid network composed of large size units at Ahmedabad and Surat, Tata's thermal station at Trombay and their hydro-electric installations in Bhivpur, Bhira and Khopoli, and the Government thermal plant at Chola as well as the new hydro-electric station at Koyna, the uneconomic size sets at Ahmedabad, Chola and Surat would be removed to colliery heads or to a site nearer Bhusaval to serve the local developments, both present and prospective, and their place taken by larger sets of higher steam pressure and temperature. Although the Tarapur nuclear station would be using uranium for fission when in operation, it will produce plutonium which in combination with India's more abundant thorium will provide fission fuel for the stations proposed to be erected elsewhere. The value of plutonium received from its reactors would be offset against that of uranium charges.

Finally, the cost of an oil-fired station based on the new Cambay and Ankleshwar fields would only be slightly lower than a coal-fired one. Petroleum's use in the near future would lie in its replacing coal in rehabilitation or extension programmes for switch over from the solid fuel at Ahmedabad, Surat and Chola, or its utilisation at Trombay where furnace oil is being burnt in the boilers of the two sets in operation. Thus outlets could be found for the oil discovered and now being developed by the State-sponsored Oil and Natural Gas Commission at Cambay and its environs.

Centenarian Engineer

The hundredth birthday of Sir Mokshagundam Visvesvaraya, M.I.C.E., K.C.I.E., India's veteran engineer and statesman, was celebrated throughout India on September 15, 1960. Born on September 15, 1861, educated at the Central College, Bangalore, and College of Science, Poona, he entered the Public Works Department, Bombay Presidency, as Assistant Engineer in 1884. Promoted Executive Engineer in 1899 and Superintending Engineer five years later, he retired from Government service in 1908. His official life was marked by great achievements like the Lakefife irrigation project near Poona, and water supply and sanitary schemes in several cities of the Bombay Presidency and other Indian States. As he was laying down his office this eminent engineer was requested by the then Secretary of State for India to prepare a plan of water supply for Aden. He terminated his services at Bombay prematurely so as to devote the rest of his life to the industrialisation of India, and with that object undertook a world tour to study conditions abroad.

Ever since then several provinces and States of India have had the benefit of Sir Mokshagundam's sane advice and sound schemes. Following the devastating floods in Hyderabad, and at the special request of the Nizam, he planned and executed Oosman Sagar, and so saved that city once and for all from flood menace. At the pressing request of the late Maharajah of Mysore he accepted service as Chief Engineer on the express condition that his advice on economic improvements should receive the ruler's prompt and sympathetic consideration. In this capacity, and subsequently as Dewan (Prime Minister) of this model state, he conceived and brought to fruition many impressive schemes like the Krishnaraja Sagar Dam, the Bank of Mysore, the Mysore University, the Bhadravati Iron Works and the Mysore Chamber of Commerce.

Even after retirement Sir M. Visvesvaraya continued to evince lively interest not only in Mysore but throughout India. As chairman of the very first planning commission he rendered valuable service, and was besides one of the architects of the now historic Bombay Plan. He had the foresight to launch the All India Manufacturers' Organisation, and was its Founder President. During the past decade he had been striving to strike a balance between centralised and decentralised production and his efforts in this direction have met with a large measure of success. His outstanding publications include *Reconstructing India*, 1920 ; *Planned Economy for India*, 1934 ; and *Memoirs of My Working Life*, 1951. His vision, zest for work and high moral character, combined with his abiding passion to make India take her rightful place in the comity of nations, ensure Sir Mokshagundam a place in history as one of India's greatest sons and benefactors. To perpetuate his memory it has been decided to build an Industrial and Technological Museum and Library, computed to cost Rs.25 lakhs. Already the Mysore Government have donated a valuable site at Cubbon Park, Bangalore.

CONTINENTAL AFFAIRS

by Our Continental Editor

Göschenen Power Scheme

With the impending completion of the Göschenen power scheme, annual electricity production in Switzerland will be stepped up by 525 million kWh, of which 425 million kWh will come from the scheme itself, and 100 million kWh will result from improvements to other stations which the Göschenen development has made possible. Some 47 per cent of the output will be winter power, and the annual total will be shared equally between the Swiss Federal Railways and the Central-Schweizerische Kraftwerke Power Company. The scheme comprises two independent stages, the seasonal storage plant Göscheneralp–Göschenen (160MW) and the run-of-river plant Andermatt–Göschenen (32·5MW), the whole of the machinery being installed in a common underground power-house. Division of power between 16⅔ c/s single-phase and 50 c/s three-phase generation is carried out on the water side. Two of the three single-phase generators are machines of 50MVA and are stated to be the largest of their kind at the present time.

AFTER a period of construction of 5¼ years, the first three sets of Göschenen power station are coming into operation early this year. With the addition of a further three sets next spring, work on this important scheme will be concluded. With a total installed capacity of 192·5MW, the station will itself generate 425 million kWh per annum and its operation will enable two downstream run-of-river stations, Wassen and Amsteg, to increase their annual output by 100 million kWh. Forty-seven per cent of this total of 525 million kWh will be winter power, and the electricity will be shared on a 50 : 50 basis between the Swiss Federal Railways (SBB) and the Centralschweizerische Kraftwerke A.G., Lucerne (CKW).

The scheme thus is of great importance, both to the railway to which it will furnish a large proportion of the additional traction current required in the next twenty years, and to the Swiss industrial grid. Substantial benefit will also come to the Canton of Uri which has already gained considerably from the employment created by the construction, and will derive a revenue of about 1·3 million Swiss francs per annum from income tax and water rights.

The Göschenen scheme exploits the headwaters of the Reuss in two hydraulically and electrically independent stages, the sets for which are, however, being housed in the same underground machine hall. Fig. 1 shows the total catchment area of 239·9 square kilometres, 17 per cent of which is glaciated. In the stage Göscheneralp–Göschenen, the waters from an 88·4 square kilometres catchment with 32 per cent glaciation, are collected in a reservoir—the Göscheneralp reservoir—and utilised over a gross head of approximately 616m to 708m. The stage Andermatt–Göschenen receives the water from 151·4 square kilometres. Fig. 2 shows the principal elevations.

The key piece of the scheme is the Göscheneralp reservoir of 75 cubic hectometres, thanks to which it is possible to achieve an economic proportion of winter power. Situated 1700m above sea level, it is formed by a rockfill dam with a maximum height of 155m, a length along the crown of 540m, and a volume of 9,000,000 cubic metres. This is the largest structure of its kind in Switzerland and the second largest in Europe, being surpassed only by the Serre Ponçon dam (which has a height of 122m, a length of 600m, and a volume of 14,000,000 cubic metres). From the angle of construction cost also the dam provided the key to the whole scheme. Not until the advent of modern earthmoving equipment could such a rockfill dam—in itself desirable for military reasons and in order to preserve amenities—be constructed comparatively cheaply. In the present case, an equivalent concrete gravity dam would have cost about 50 per cent more ; it was for that reason that a scheme elaborated in 1946 on the basis of a concrete dam had to be shelved as uneconomic.

Plans for the exploitation of the River Reuss go back to the early days of railway electrification. Already in 1907 the Canton Uri granted a fifty-year concession to the Gotthard Railway Company for the sole use of the water power between Urnerloch near Andermatt and Amsteg, including the tributaries Meienreuss, Fellibach and Kärstelenbach. When the SBB was set up, it took over the Gotthard Railway Company and with it the concession which enabled it in 1916—spurred on by the then existing coal shortage—to begin the electrification of this main traffic artery. The section Erstfeld–Airolo was changed over to electric traction at 15kV, 16⅔ c/s in October, 1920, and Airolo–Biasca followed a few months later. The energy was supplied by the newly commissioned Ritom hydro-electric station, the first SBB-owned power plant. In the years until 1928 that station was followed by Amsteg, Göschenen substation, Barberine, Vernayaz, Trient substation, and Massaboden. At that time it was thought that these stations would be capable of supplying the requirements of the railways for years ahead, but nevertheless steps were taken to secure additional supplies of electricity for dry years or in case power stations had to shut down temporarily. Agreements were concluded in 1924 with Bernische Kraftwerke A.G. (BKW) and in 1925 with A.G. Bündner Kraftwerke (BK) for the supply of single-phase current. On the other hand, three-phase generators were installed at Amsteg and Vernayaz, so as to be able to supply surplus energy to the grid. Agreements with Nordostschweizerische Kraftwerke A.G. (NOK) lend to the construction of the "shared" power stations Etzelwerk (1937), and Rupperswil-Auenstein (1945), and by means of asynchronous converter sets at Mühleberg (BKW) and Seebach (NOK), industrial current was made available to the railways.

Owing to the world economic crisis, annual consumption of traction current increased only slightly between 1928 and 1936, viz. from approximately 460 million to 560 million kWh, about 10 per cent of which came from private power companies. The fuel shortage during the second world war then led to a shift in the traffic to the railways whose annual demand nearly topped 800 million kWh during 1941-45. Contrary to what happened after the first world war, the years following the second saw an unpredicted increase in rail transportation. Between 1948 and 1957, average daily passenger mileage figures rose from 123,000 to 144,000, and annual gross tonne-kilometres of passenger trains rose from 9 to 11,000 million. Goods traffic expanded even more rapidly, from 6000 million tonne-kilometres gross in 1948, to 26,000 million tonne-kilometres gross in 1957. During the same period consumption of current rose from 881 million kWh to 1174 million kWh, and is expected to reach 1400 million kWh in 1968.

At the end of 1945, the SBB disposed of an annual generating capacity of 755 million kWh (based on a hydraulic year with low run-off, such as 1908-09). This was obtained from the above-mentioned nine, fully-owned or shared power stations and substations. By expanding and

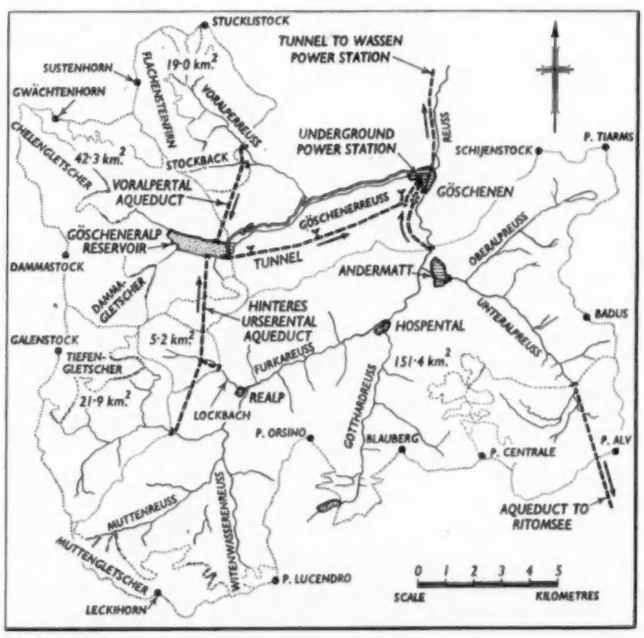


Fig. 1—Catchment area covered by Göschenen scheme

CONTINENTAL AFFAIRS *(Continued)*

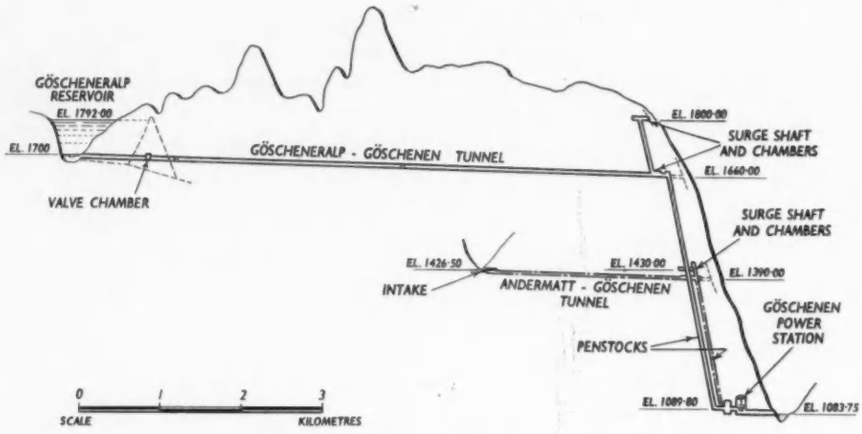


Fig. 2—Diagrammatic elevation of Göschenen power scheme

improving Barberine, Massaboden and Ritom it was found possible by the end of 1953 to raise this figure by 92,000,000 kWh (or 114 million kWh in the average hydraulic year).

Since this output was insufficient to satisfy its needs, the SBB entered into agreements with various Swiss power companies to supply 145 million kWh per annum, in addition to which it obtained an option on a further 40,000,000 kWh from Swiss sources and on another 40,000,000 kWh (in 1959 and 1960, 80,000,000 kWh) from the German Federal Railway (DB). All these measures, while sufficient in normal years, would still have left a deficit of some 250 million to 300 million kWh in a dry year.

This prospect, together with the anticipated further growth of the traffic, made it imperative to provide additional generating capacity. From 1963 onward, this will yield a further 356 million kWh in a dry year, and about 440 million kWh in the average year. Of this total, Göschenen, when completed, will supply 160 million kWh, the derivation of the Unteralpreuss into the Ritom reservoir will yield a further 26,000,000 kWh, and the increase in output from Amsteg will amount to 40,000,000 kWh. In 1962, a further converter station will be put into service in the Ticino, and finally, the commissioning of Amsteg II in 1963 will add 80,000,000 kWh. After 1963, therefore, there should be available to the SBB a total of 1350 million kWh in a dry year, and 1650 million kWh in a normal hydraulic year. The lower figure does not quite cover the expected demand, leaving some 100 million kWh to be made up by savings and additional purchases. In an average year, however, there would be a surplus of the order of 200 million to 280 million kWh which the SBB thinks can easily be sold to the grid, since the national demand increases about twice as fast as that of the railways.

Surplus energy can readily be supplied to the grid by Göschenen Power Station because the division between 50 c/s industrial generation and 16⅔ c/s railway generation is made on the water side. This arrangement avoids the need to instal an extra 50 c/s generator as at Amsteg. The turbines and electrical equipment are entirely separate in each system.

The preceding paragraphs briefly sketch the position of Göschenen in the wider scheme of the expansion of the SBB. The legal basis for the power station lies in an extension of the 1907 agreement, which the SBB negotiated with the Canton in 1929 and which besides prolonging the concession until the year 2008 also includes the Reuss from the Sprengi bridge to the confluence of the Göschenenreuss—which in 1875 had already formed the subject of a concession to the Gotthard Railway Company—and the Reuss section from St. Anton's Kapelle to Teufelsbrücke (for which the Military Department had been given a concession in 1889 which it had not used).

In 1944, the CKW was given a sub-concession by the SBB for Andermatt-Wassen, and by the Canton for the Göscheneralpreuss and Voralperreuss up to 1680m sea level. The result was the construction, in 1944-49, of the run-of-river plant Wassen which exploits the Reuss between Göschenen and the SBB equalising basin Pfaffensprung. This station has a mean annual generating capacity of 235 million kWh. Although there is a small daily storage basin at Göschenen which is useful for the upgrading of winter energy, the lack of seasonal storage led to considerable wastage of water in the summer.

This fact caused the SBB and CKW in 1952 to apply jointly to the Canton Uri for a wider concession covering also the Göscheneralpreuss and Voralperreuss, together with the construction of the Göscheneralp seasonal reservoir and the derivation of the Furkareuss into it. After negotiations lasting two years, the Landrat on September 22, 1954, gave a favourable decision, validating the concession until the year 2043. The right under Swiss law to subject the verdict to popular referendum was not taken up and lapsed at the close of the year. This cleared the way towards the realisation of the scheme for which purpose the "Kraftwerk Göschenen A.G." power company was set up in 1955, with a share capital held to the extent of 50 per cent by CKW, 40 per cent by SBB, and 10 per cent by the Canton Uri.

Dam

The reservoir lies at the head of the valley of the Göschenerreuss, approximately 8 km west of the village of Göschenen. Situated at approximately 1700m above sea level, the area of the so-called Göscheneralp is a comparatively level stretch of the valley running west to east. There the Göschenerreuss takes its origin from the confluence of two tributary glacier streams, the Damma and Chelen Reuss. At the exit of the alp, the valley narrows somewhat before falling away more steeply, and it was this point which was chosen for the site of the dam.

The valley bottom is formed by fluvio-glacial deposits of 36·5m average thickness. These deposits vary considerably and include fine sand and gravel as well as large blocks and scree, the latter in particular along the right (southern) flank. At the dam axis a sill of bedrock runs between the two sides of the valley. This, however, is cut through by two channels, the smaller one on the left flank of the valley filled to a depth of 10m with sands and gravels forming the bed of the river. The second, larger one was found to be about 70m deep and filled with alluvia and debris to the level of the surrounding land. The granitic bedrock, polished by glacier action, slopes away on either side of the sill.

In order to achieve a reservoir with the desired difference of 92m between the maximum and minimum levels, either a rockfill dam of 9,000,000 cubic metres or a concrete gravity dam of 2·1 million cubic metres would have been required. The cost of the former was estimated to be 80,000,000 Swiss francs (£6·6 million) while the latter would have cost about 50 per cent more (£10,000,000).

The economy of the construction depended largely on the possibility of using local materials and the ease with which these could be got. On the Göscheneralp the situation was on the whole favourable although in view of the heterogeneity of the strata careful control had to be exercised over the composition of the batches. With the exception of the clay component of the core, all of the rockfill was obtained from excavations near the dam site.

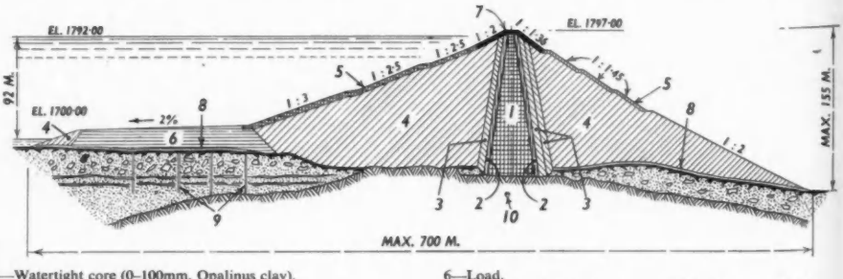
Fig. 3 shows the cross section of the dam which may be seen to comprise a central watertight core, rising approximately above the crest of the rock sill.

The two alluvia-filled channels in the sill, although adequately load-bearing, would have formed a leakage path under the core. In order to make quite sure of obtaining perfect watertightness, it was decided to clear away this material, rather than try to render it impervious by an injection apron or in some other manner. The two channels accordingly were excavated, involving the removal of about 1,000,000 cubic metres (Fig. 4).

On the valley flanks the core directly abuts the rock, while on both water and air side it is faced by filter and transition layers and supported by heavy masses of rockfill which account for about 80 per cent of the whole volume. The principal data are shown in Table II.

The choice of a quasi-symmetrical section with central core was made after lengthy soil-mechanical investigations. The slopes were chosen so as to ensure stability during the various stages of construction, and later with a full reservoir as well as under rapid draw-down conditions, both during the first few years while consolidation was still incomplete, and after a few decades of operation. Earthquake forces were also taken into account.

Calculation showed the need for additional support on the waterside, in particular on the left bank of the Reuss, and it was decided to



1—Watertight core (0–100mm, Opalinus clay).
2—Filter layers (0–100mm).
3—Transition layers (alluvium 0–200mm ; air-side outer layer 8mm–200mm).
4—Rockfill (maximum grain size 1 cubic metre).
5—Protective layers, packed on water-side (maximum grain size = 1 cubic metre).
6—Load.
7—Protective cladding on crown, 2-3 cubic metre blocks.
8—Drainage layer.
9—Vertical drains (sand drains).
10—Injection and control tunnel.

Fig. 3—Cross section of Göscheneralp dam

Fig. 4—Excavation for the core foundation (July, 1957). A total of 1,000,000 cubic metres of material had to be removed

Fig. 6—Placing of the core material (September, 1958). Core and filter zones are partly under roof

place extra filling material there. However, the inferior degree of permeability of the subsoil—which consists of alluvium with horizontal layers of peat and fine sands—would have led to the building up of high water pressures in the pores endangering the stability of the dam. Installation of vertical drainage in the form of a number of sand drains removed this danger.

Core.—In spite of the variable nature of the deposits, local alluvia of fine sands and silt could, with suitable preparation, have yielded an adequately impervious core material. This would not, however, have been sufficiently resistant to erosion. Normally clayey soil is used as a binder, but such soil is completely absent from the vicinity. It thus became necessary to bring clay from a distance. The choice lay between bentonites of foreign origin and Opalinus clay, deposits of which are found at Holderbank (Aargau). Eventually it was decided to use the native material.

With a thickness of only 44m at the base, and 5·5m at the top, the approximately 130m to 150m high core represents a volume of 800,000 cubic metres. It was found that in order to keep the clay additions to a minimum, the proportion of fines below 0·02mm must not be allowed to fall below 3 per cent ; coarse aggregate was employed up to a size of 200mm. Opalinus clay was added at the rate of 220 kg to 250 kg per cubic metre of finished core material. Some 230,000 tonnes of the clay were required which at a cost of about 40 Swiss francs per tonne represented a major fraction of the whole construction cost. Thanks to careful preparation, an average k-value of less than 1×10^{-7} cm/sec was obtained.

Filter and Transition Layers.—For protecting the core faces against erosion, graded filter layers were placed on both sides, with grain sizes and permeability increasing towards the outside. Most of the material for these layers also came from the alluvium of the valley.

Injection Apron.—Underneath the core a waterproof apron was installed by injecting the rock with a mixture of cement and Opalinus clay, which was considered to be cheaper than the use of pure cement grout. The depth of this apron reaches down to 180m below the rock surface. Drillings were spaced mostly 6m apart and only occasionally at distances of up to 12m. The amount of material injected was comparatively high, viz. some 220 kg of dry material per metre drilled, or 37 kg per square metre of apron. This appears to confirm observations made elsewhere that the local kind of granite (Aare granite), though of great strength, is liable to much fissuring on account of its brittleness. In addition to the apron, a large number of superficial injections were carried out, 6m to 8m apart, all over the area of contact between core and rock : these further prevented leakage and local erosion.

Core Preparation and Placement.—Material for the core was excavated from the valley bottom upstream of the dam in two levels, each 5m deep, and conveyed by dumpers of 8 to 12 cubic metres capacity to the preparation plant (Fig. 5). After screening out sizes over 200mm, the remaining material was conveyed to vibratory screens and separated into components 0–30mm, 30mm–100mm, and 100mm–200mm, with addition of crushed material to make good any shortage of coarse sizes. In spite of artificial drainage of the pits, the moisture content of the sand was excessive, necessitating the partial drying of the 0–30mm component in four oil-fired kilns, as well as the roofing over of the sand depots. About 25 tonnes of fuel oil were consumed daily by the drying plant. Five silos of 1000 tonnes each were used for storing the already dried and ground Opalinus clay which arrived by lorry from the railhead at Göschenen, at the rate of 600–700 tonnes per day. Clay and aggregates were brought by belt conveyors to the triple mixing towers where six mixers were installed. From the mixing plant, the core material was taken by dumpers to the site where it was spread by bulldozers in 25cm to 35cm thick layers, and compacted by pneumatic rollers with weight adjustable up to 50 tonnes. In places inaccessible to the rollers, hand-operated vibrators were used. Special attention was paid to preparing the rock prior to placing the core, carefully cleaning away loose material with compressed air or water jets, removing re-entrant angles and grouting any remaining cracks. Finally, a plastic contact layer with a high clay content, with no coarse material, was put down.

A rather critical factor was the maximum permissible moisture content of the material for the core and inner filter layers. In order therefore to make sure of at least eighty working days in each of the three building seasons, part of the core was covered by 20m by 40m portable steel roofing (Fig. 6).

The moisture content chosen was slightly above that which would have given maximum

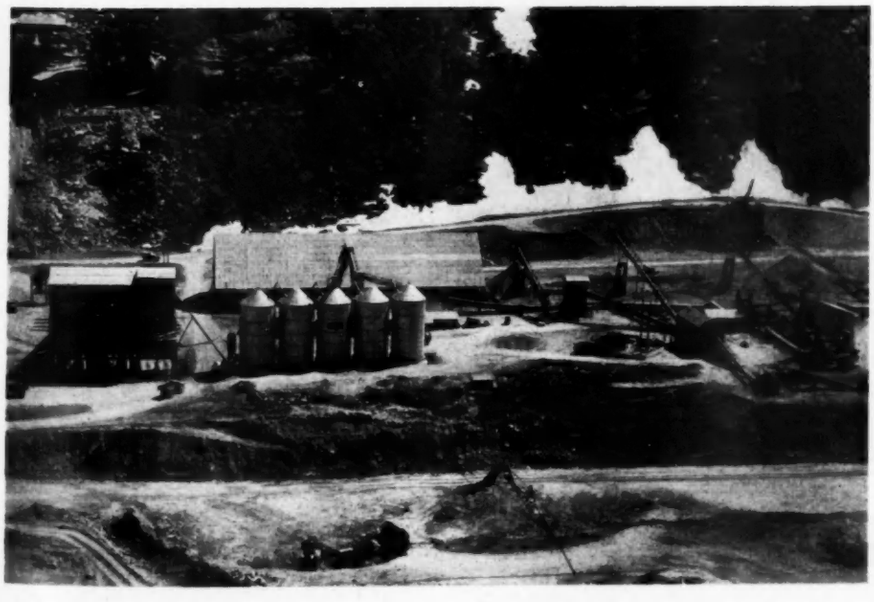


Fig. 5—Screening and mixing plant for core material : (background, right) prescreening plant ; (centre, left to right) storage areas for fine and coarse material, some of the former under roof ; (foreground, left to right) six-unit mixing tower, five 1000-tonne clay silos and drying plant with four rotary kilns

CONTINENTAL AFFAIRS *(continued)*

Fig. 7—Downstream view of dam nearing completion (July, 1959)

consolidation. Although in this way the amount of settlement was somewhat increased, impermeability was improved and the core had a greater plasticity. Because of its slenderness and comparative small weight in relation to the rockfill, the reduction in stability did not matter. The fact that less drying of the materials was required constituted an important saving.

Rockfill.—Generally the ground was adequately loadbearing to support the weight of the dam, except under the waterside footing. There, however, the presence in the subsoil of inadequately porous layers of silt and peat would have prevented a sufficiently fast escape of the groundwater, which would have lead to a dangerously high water pressure in the pores of the soil. Accordingly, twenty-six vertical sand drains were installed with diameters ranging from 45cm to 85cm and up to 39m long. These drains were constructed in 1956 within only 2½ months. Consolidation was speeded up by putting down in this area 15m to 20m of rockfill.

After two years, settlement amounted to 1·0m and measurement of interstitial water pressure showed a drop to 10 per cent. of the overburden pressure, instead of only 70-80 per cent without drainage.

Rockfill material was quarried from the slopes on the right flank of the reservoir by heavy excavators with 3 cubic metre buckets, and transported to the dam by dumpers. Large-scale trials involving 30,000 cubic metres were carried out in 1955 at the dam site in order to determine the best method of placing the rockfill, and it was decided to build up the fill by dumping in 2·5m high layers, with addition of 1·5 cubic metres of water to each dumper load of 10 cubic metres, but without any mechanical consolidation. Maximum grain size was 1 cubic metre and 1·5m diameter. Permeability of the rockfill varied between $k = 10^{-2}$ and 10^{-5}cm/sec necessitating the carrying out of model tests in order to determine the time required for drainage when lowering the reservoir level. Fig. 7 shows the dam nearing completion

Field Laboratory.—A field laboratory for soil-mechanical investigations and current quality control was set up in 1950 and began full operation in 1957. In the later stages, personnel included one graduate and one non-graduate engineer, one supervisor, fourteen laboratory technicians and eighteen assistants. Altogether forty-four men were occupied fully and eight part-time with the control of materials.

Contractors' Plant and Installations.—Inaccessibility of the site required the building of an expensive road in order to enable heavy equipment and materials to be brought up from Göschenen. The minimum width of this 11km long road is 4·2m. In addition, about 20 km of 10m wide tracks, with 10 per cent maximum gradient, had to be built locally at the site which extended over 3·5 km.

The programme involved earth movements averaging 500,000 cubic metres per month and rising to a maximum of 700,000 cubic metres per month, during campaign seasons of 120 to 150 days per annum. This was achieved by deploying a work force of 700 to 800, mechanised to the extent of 50 h.p. per man. Machines comprised twenty-four heavy excavators with buckets of up to 3 cubic metres (total bucket capacity, 47 cubic metres), twenty-four bulldozers of 180 h.p. to 320 h.p., eighty heavy pneumatically tyred vehicles, including two 22 cubic metre dumper trucks, and a number of tankers, concrete mixers, mobile cranes and auxiliary vehicles.

Reference has already been made to the preparation plant for the core and filter materials and to the portable roofing over the core during construction.

The choice of sites for the fixed installations was largely governed by considerations of security from avalanches. Thus the various sections of the preparation and mixing plant were sited in the shelter of the depot piles. Generally the plant was dispersed as much as possible, on which account considerable extra expenditure was involved, e.g. 2 km of conveyors and 8 km of multicore cable had to be placed.

Total installed power amounted to 40,000 h.p., of which electric motors accounted for 4800 h.p., Consumption of diesel oil averaged 21,000 litres per day, with a maximum consumption of 35,000 litres per day ; daily oil consumption averaged 800 to 900 litres.

Work proceeded in two successive ten-hour shifts. Efficient lighting during the hours of darkness was provided by some 130 searchlights, each of 1500W.

Accommodation, canteen and recreation facilities, including a cinema with 200 seats, were provided near the site, and further accommodation for eighty mechanics and fitters at the 1250 square metre maintenance workshop near Göschenen, as well as married quarters for employees in the village.

Derivation Tunnels

Hinteres Urserental.—A 7·2 km long tunnel is being constructed to add the waters of the Lochbach (intake at 2015m above sea level) and the Furka Reuss (intake at 1816m above sea level). Work began in 1956 and for the first 3·5 km proceeded smoothly in Aare granite. It has since been greatly hampered by an inflow of water which gradually increased from 40 to 300 litres per second. About one-fifth of this

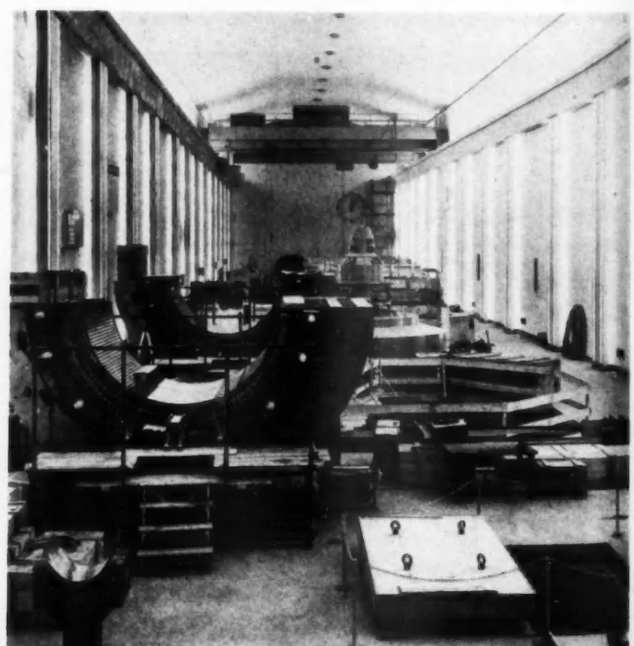


Fig. 8 — Underground power-house. One of the two 50MVA single-phase generators has been erected, the two stator halves for the second machine are on the left

tunnel runs through carboniferous perm and mesozoic rocks ; this is almost the only time that rock other than granite is being encountered.

Voralpertal.—This tunnel will add the water of the Voralperreuss and Stockbach, with intakes respectively at 1840m and 1860 m above sea level. The length of the tunnel is 3900m.

Spillway

A spillway with fixed sill is provided at the northern side of the reservoir and discharges into a lateral spill race and tunnel communicating with the mid-level spill culvert at 1781m above sea level (16m below the crown of the dam). Together, these can drain off 200 cumecs, at an impounding level of 1793m above sea level (1m above normal level). Such a spill rate corresponds to $4 \cdot 7 m^3/sec/km^2$ of catchment and may appear high, but was considered necessary from the point of view of safety of the dam.

Pressure Tunnel and Penstock

From the reservoir, a 7·2 km long pressure tunnel of 3m internal diameter leads inside the right flank of the valley to the surge chamber at Rötiboden. The intake is controlled by two butterfly valves situated in a valve chamber approximately at the dam axis ; the injection tunnel under the dam forms a convenient connecting passage between this valve chamber and that of the bottom outlet.

An inclined surge shaft connects the two surge chambers at 1660m and 1800m sea level. The water descends to the turbine through a penstock of 2·4m internal diameter, reducing to 2·2m, and sloping at 80 per cent (0·5 per cent over the final section). The wall of the penstock which is lined with " Soudotenax 44 " and " 52 " special steel, increases in thickness from 15mm to 22mm. The distributor is of " Aldur 50 " steel.

Andermatt—Göschenen

The intake weir at Urnerloch dates from 1942. The intake has been widened and is followed by a 75m long underground desander. Through a sloping shaft the water reaches the 2·4 km long pressure tunnel of 2·2m internal diameter which follows the left flank of the Schöllenen gorge to Stockwald where twin surge chambers like those at Rötiboden are installed. The pressure penstock of 498m length and 1·7m internal diameter runs parallel with that from the Göscheneralp reservoir. The lining has a constant thickness of 13mm, but the steel quality is graded, ranging from " Soudotenax 35 " to " 41 " and " 44 ".

Power-House

All six sets—the four belonging to Göscheneralp and the two belonging to Andermatt—are housed in a common underground power-house placed in an excavation 118m long, 20m wide and 31·4m high (Fig. 8). Upstream 22·5m away is the valve chamber which drains through a culvert into the Reuss and so protects the power-house from becoming flooded, should there be a failure of a penstock or valve.

The tailrace is connected to the small daily storage basin of Wassen power station, to which later on there will also be joined the projected Amsteg II power station.

Control building and repair shop, as well as the transformers and switchgear, are outside the mountain on the bank of the Reuss.

Machinery

Göscheneralp–Göschenen.—This section of the scheme operates under a gross head of 616m to 708m and has an installed capacity of 160MW, comprising four three-jet, vertical Pelton turbines each of 56,000 h.p. capacity at 500 r.p.m. and designed for a flow of 7·5 cumecs under a net head of 650m.

The turbines drive two three-phase generators, each of 53,300 kVA, cos $\phi = 0 \cdot 75$, generating at 10kV and 50 c/s ; and two single-phase generators of 50,000kVA, cos $\phi = 0 \cdot 80$, generating at 13kV and $16\frac{2}{3}$ c/s.

Andermatt–Göschenen.—This run-of-river plant is designed for a gross head of 343m and a total flow of 12 cumecs at 322m net head. The installed capacity of 32·5MW comprises a three-phase generator of 22,000kVA, cos $\phi = 0 \cdot 75$, generating at 10kV and 50 c/s, and a single-phase generator of 20,000kVA, cos $\phi = 0 \cdot 80$, generating a 13kV, $16\frac{2}{3}$ c/s. Each of these machines is driven at 333 r.p.m. by a three-jet, vertical Pelton turbine of 22,600 h.p. Each section in addition comprises a station set of 750kVA, 380V.

Transformers and Switchgear.—There are two three-phase transformer groups each comprising three single-phase, 10/220kV transformers rated at 17,766kVA ; one three-phase, 10/50kV transformer of 22,000kVA ; four single-phase transformers, 13/132kV, 25,000kVA ; two single-phase regulating transformers 13/66kV, 10,000kVA ; and one single-phase transformer, 13/132kV, 20,000kVA.

Power is transmitted to Amsteg–Rupperswil and Göschenen substation (SBB), as well as Mettlen (220kV, later 380kV), with a connection to the grid of Altdorf power station.

Control Equipment.—With the exception of starting up the sets all operations are controlled from the main control room. The control panels are let into a frame and connected by plugging in, an arrangement which allowed the connections to be wired beforehand. The panels were not set-up until the building work had been completed, thereby avoiding any possible damage to instruments. It is also easy to interchange the panels should the need arise. There are four sets of panels, the main panel which forms a curved façade facing into the control room, and three subsidiary panels at the back.

The left-hand side of the main control panel contains the $16\frac{2}{3}$-cycle system on the left, the 50-cycle system on the right, and the hydraulic system in the centre. Each section is provided with a mimic diagram indicating from incoming signals the actual state of the various control organs. The indicators take the form of circular windows showing differently coloured spherical sectors. Commands are given from control desks of which there is one for each section ; first the wanted connection is set up by push-buttons then a common control switch is actuated to transmit the command. The control switch is the same for all control organs in the same panel section ; this saves a great deal of space. The main hydraulic panel contains indicators and integrating indicators for all the principal water levels and flow quantities, including the levels of the daily reservoirs. The subsidiary hydraulic panel at the rear continuously registers the product of flow and head of each group in order to determine the energy used by each of the partners, SBB and CKW. This cannot be determined by registering the electrical output because of differences in generator efficiencies, heads, and duration of operation. These measurements are also carried out in order to maintain the minimum summer flow in the Schöllenen gorge as laid down in the concession.

Carrier frequencies are employed to transmit instrument readings, commands and telephony on the transmission lines of both generator frequencies. In addition, a loudspeaker telephone system connects the control room with the machine hall, open-air switching station, valve chambers and other parts of the station. The loudspeakers also transmit warning and alert signals when necessary.

The plant is heated by a heat pump of 340,000 k cal per hour capacity, which uses the waste heat from the generators. The flow of water through the generator air-coolers is regulated to give a constant outlet temperature of 24 deg. Cent, in order to allow the heat pump to work with maximum efficiency. Supplementary electric heating is provided for very cold days or when the generators are standing still. An air-conditioning plant circulates continuously 35,000 cubic metres per hour of air through the underground power-house, to which over 10,000 cubic metres per hour of fresh air are added. Two climatic zones are maintained, one comprising spaces much frequented by personnel, where a comfortable atmosphere is maintained, the other is designed to prevent condensation in rooms housing machinery which are kept cool and dry. A further 36,000 cubic metres per hour of fresh air are circulated through the busbar channel to limit the temperature there to 40 deg. Cent.

TABLE I—*Principal Data of Göschenen Power Scheme*

	Göscheneralp	Andermatt	Total
Reservoir	75×10^6 cubic metres	—	—
Natural catchment	42·3 square kilometres	151·4 square kilometres	—
Voralpertal derivation	19·0 square kilometres	—	—
Hinteres Urserental derivation	27·1 square kilometres	—	—
	88·4 square kilometres	151·4 square kilometres	239·8 square kilometres
Glaciation, approximately	32 per cent	8 per cent	17 per cent
Mean annual flow	6·22 cumec	7·72 cumec	—
Design flow rate	30 cumec	12 cumec	—
Gross head, approximate	708m–616m	343m	—
Installed capacity	4×40kW	16·5MW 16MW	—
	Comprising :	Comprising :	
	Two generators, three-phase, cos $\phi = 0 \cdot 75$, 10kV, 53·3MVA, 50 c/s	One generator, three-phase, cos $\phi = 0 \cdot 75$, 10kV, 22MVA, 50 c/s	
	Two generators, single phase, cos $\phi = 0 \cdot 8$, 13kV, 50MVA, $16\frac{2}{3}$ c/s	One generator, single-phase, cos $\phi = 0 \cdot 8$, 13kV, 20MVA, $16\frac{2}{3}$ c/s	
Mean annual generation (millions kilowatt hours) :			
Winter	137	22	159 (247)
Summer	183	83	266 (278)
Total	320	105	425 (525)

Figures in brackets are inclusive of additional production in Wassen and Amsteg power stations.

TABLE II—*Göscheneralp Reservoir*

Normal impounding level	1792m above sea level
Lowest impounding level	1700m above sea level
Useful volume	75×10^6 cubic metres
Rockfill dam :	
Maximum height	155m
Crown, elevation	1797m above sea level
Maximum width	700m
Crown length	540m
Crown width	11m
Volume	9×10^6 cubic metres
Diversion/bottom outlet, length	1760m
Injection tunnel under core, length	520m

Single-Phase Generators

The two current systems—three-phase current at 50 c/s and single-phase current at $16\frac{2}{3}$ c/s—require quite different designs of generator. In the single-phase machines, the low frequency and only partial utilisation of the core results in a considerable increase in size as compared with three-phase, 50 c/s machines of similar output. Whereas three-phase machines of 50,000kVA are in no way unusual, the two large single-phase generators of the Göscheneralp–Göschenen stage are believed to be the largest water-turbine-driven units of this kind in existence, and incorporate many new design aspects. Designed and built by Maschinenfabrik Oerlikon, they are four-pole machines running at 500 r.p.m. and generating current at a voltage of 13kV ±10 per cent, (Table III). A similar layout has been adopted for all six main generators at the Göschenen power station, viz. vertical arrangement below floor level, closed-circuit cooling, and a stator supported on the casing of the triple-jet Pelton turbine which itself rests directly on the foundations. Absence of additional lateral anchoring of the machines means that they will not be affected by any settlement of the rock cavern which may occur.

TABLE III—*50MVA, $16\frac{2}{3}$ c/s Single-Phase Generators for Göschenen*

Rotor diameter	3030mm
Number of poles	four
Weight including poles, approx.	170 tonnes
Weight per pole, approx.	11·25 tonnes
Moment of inertia of rotor	2×10^4 kg m²
Rating	50MVA
Power factor	cos $\phi = 0 \cdot 8$
Output voltage	13kV

Except for its size, the stator core (Fig. 9) is of conventional design. Radial ventilation is obtained by means of air ducts which are formed between the individual core sections. The

CONTINENTAL AFFAIRS *(Continued)*

Fig. 9—Stator of 50MVA 16⅔ c/s, single-phase alternator, during assembly of the core laminations

Fig. 10—Detail of 50MVA, single-phase stator, showing the manner of supporting the coil ends

end plates and compression fingers at each end of the core are made of non-magnetic steel in order to reduce the magnetic stray losses. The unavoidable thickness tolerances within the 750mm high core sections were such that they could not be equalised by normal methods of stacking of the laminations. Two rows of compression bolts were therefore provided, of which the outer row was screwed into the housing.

Three-quarters of the complete slotted core is wound, making thirty-four slots per pole (Fig. 10). A single-layer diamond winding was found to be most suitable to facilitate short-circuit-proof clamping of the end turns. The arrangement of the coils is the same as that for a normal three-phase winding, the gaps being occupied by strong aluminium frames. These replacements for the absent winding bars are insulated from the coils and provide permanent circumferential prestress of the coils by means of spring plungers. The frames and coil groups lie on rings of "Bakelite"-impregnated wood which in turn are clamped to the stator by non-magnetic metal supports. Glass-fibre tapes are used as a secondary support only, against the large forces to be expected during short-circuit condition. The primary clamping of the coil sections is achieved by using insulated bolts. One half-coil with one conductor is provided per slot. The half-coils are constructed as interwoven bars built up from glass-fibre-insulated individual conductors. The portions of the bars lying within the slots are insulated with "Orlitsa" foil, vacuum-treated for increased strength, while the end turns are wound on to asphalt mica tape. The bars are of unusual size, viz. 22mm by 136mm.

The rotor (Fig. 11) had to be designed as a slotted wheel because of the high stresses occurring at the runaway speed of 925 r.p.m., when the peripheral speed amounts to approximately 150 metres per second. The rotor body consists of ten pole-wheel discs of high-duty cast steel, and two non-magnetic end discs which support the pole coils and the damper connections. This assembly is held together by a number of shrunk-fitted tension bolts. The two stub-shafts are bolted directly on to the two reinforced pole-wheel end discs, independently of the tension bolts.

The pole shoes, which are inserted in the pole-wheel slots, are also cast from high-duty steel. These carry thirty-two damper bars distributed over the surface of the pole, and the triple-layer pole coils. Pole cores and windings are each held in position by two keys of tempered wrought steel. An amply dimensioned damper winding is provided as this is necessary in single-phase machines for compensating the inverse field. Examination of the currents in this winding has shown that with damper bars of uniform section, the outermost bars are considerably overloaded. For that reason, the outer bars have been given a larger cross section than the inner ones and also have had their leakage gaps enlarged. The two outermost flat copper bars are bolted laterally on to the pole shoes. As the bars are approximately 3·3m long, the effects of differences in temperature between individual bars had to be safeguarded against by providing fairly flexible joints at the connection plates. Considerable forces are to be expected under short-circuit conditions between the stator end turns and the damper connections. This has made it necessary to clamp the damper connections rigidly within the pole gaps, both in the axial and the radial direction.

The triple-layer pole coils are made from flat copper strip wound on edge. Spacers were inserted between individual layers so as to form cooling-air ducts. A jig was used to assemble the pole shoes complete with coils and damper windings; the completed pole could then be slid into position, or subsequently dismantled, in a very simple manner. The rotor weighs 170 tonnes. It was works-tested in the over-speed pit at 925 r.p.m. for two minutes.

The rotor bearings are of normal design; the thrust bearing is built into the bearing spider above the stator and is combined with the upper generator journal bearing. Both bearings are cooled by means of a cooling coil installed in the oil bath surrounding the bearings. The lower generator journal bearing is also used to guide the overhung Pelton wheel. Cooling here is provided by a coil cast into the bearing lining and another situated in the oil reservoir.

Owing to the asymmetrial layout of the turbine jets, the lower generator bearing is subject to a radial force of 40 tonnes at full load. The design of this bearing was further complicated by the fact that the turbine is required to operate occasionally with all possible combinations of jets working, with the result that the resultant radial force on the bearing may act in a number of different directions, and care had to be taken not to have oil grooves in the immediate neighbourhood of one of these load directions. The high construction brought about by the auxiliary machines made it necessary to incorporate a further guide bearing between the main and auxiliary exciters. This bearing is insulated in order to prevent stray currents from flowing through it.

The torque of a single-phase machine pulsates at twice the generated frequency, between zero and twice the rated torque. In the case of the Göschenen generators, the circumferential force acting between the stator and the foundation fluctuates between zero and 50 tonnes. As such pulsating forces have previously led to serious damage to the foundations of similar but much smaller machines, it was decided to adopt experimentally a mounting which is elastic in the circumferential direction. It consists of two rings, one resting on top of the other. The lower of these rings is bolted to the foundation ring while

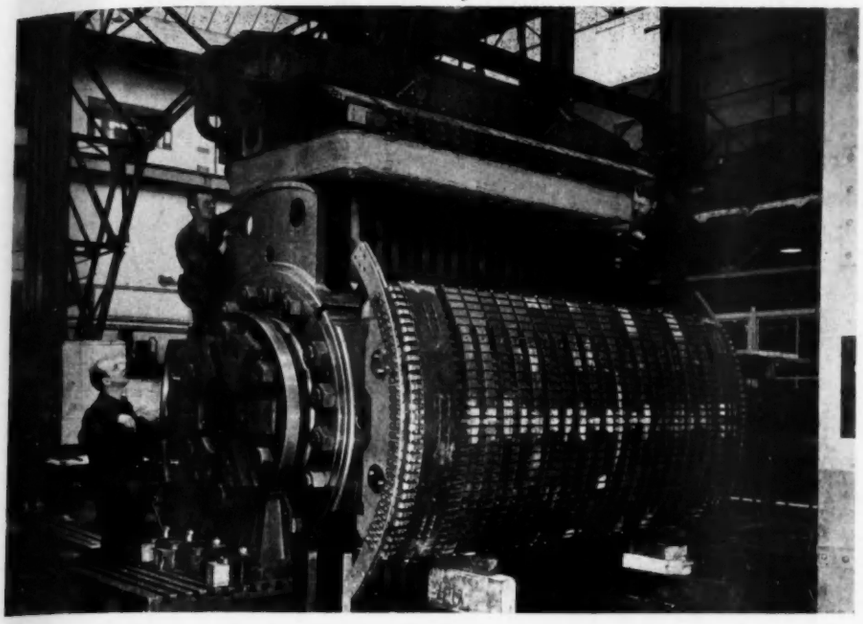


Fig. 11—Assembly of the rotor poles of 50MVA, 16⅔ c/s, single-phase alternator

the upper one is bolted to the stator. Between the two rings are spring units each of which consists of two spring plates. The design comprises eight such units which are equally spaced around the periphery. The spring plates themselves are not bolted to the rings but are held by means of keys and clamping bolts in pocket-shaped recesses. In normal service, the circumferential oscillation has an amplitude of 0·06mm, and in the case of a short circuit at the terminals, approximately 1mm. By means of the arrangement described, the pulsating torsional forces transmitted to the foundations are reduced to approximately 15 per cent of their full normal value. Keying was chosen as the method of connection between stator and foundation as this allows thermal expansion of the stator without excessive forces being exerted upon the foundation rings.

While the torsionally elastic mounting has in the first instance been adopted for only one machine, it was one of the customer's conditions that either of the machines could be changed over from one mode of operation to the other with ease. This can, in fact, be done simply by inserting or removing the spring plates, for which purpose, however, it is necessary to raise the stator. As the weight of the complete stator is about 240 tonnes which the machine hall crane cannot lift, hydraulic jacks are built in which permit the stator to be jacked up by the required amount.

Because of the elastic mounting, all casings, cover plates and cooler elements had to be kept separate from the stator.

As the turbines are equipped with braking jets, the generators themselves are without brakes. Instead, four hydraulic rotor lifting devices are incorporated in their place.

Much attention was paid to operational safety. The temperature of the stator core and windings is being checked by resistance elements, whilst the temperature of the cooling air is supervised by resistance elements, thermostats and thermo-switches of the CO_2 fire protection installation. Thermostats, resistance elements, thermometers, and temperature rise indicators are provided for the bearings.

The auxiliary machines, which are built on to the extended upper end of the shaft, comprise a main exciter of 250kW, a p.m. dynamometric generator of 1·5kVA, an auxiliary exciter of 4·5kW, a tachometer, and a centrifugal switch.

Transport.—Because of their unusual weight and size, the rotors of the two 50MVA single-phase generators, present a difficult transport problem. Weighing 115 tonnes without pole pieces and being approximately 12·75m long, the first rotor was taken by rail from the maker's works to Göschenen station where it was transferred to a forty-eight-wheeled low-level road transporter (Fig. 12). A number of lorries were required fore and aft, the maximum horsepower over the steepest part of the road—with a 12 per cent gradient—being 700 h.p. Over the bridge spanning the Reuss the transporter was winched, in order to avoid any dangerous oscillations.

Main Contractors

The firm responsible for the design and supervision of the project is Electro-Watt, Ltd., of Zurich. Others among the principal firms engaged on the projected are listed below.

Göscheneralp Dam : Working group comprising Schafir & Mugglin AG, AG Conrad Zschokke, AG Heinrich Hatt-Haller, Bless & Co., Locher & Cie AG (all of Zurich), Emil Baumann AG (Altdorf), Losinger & Co. AG (Berne).

Göschenen Power-House, Göscheneralp and Andermatt Tunnels and Penstocks : Emil Baumann AG, Jos. Baumann (both Altdorf), Prader & Cie. AG/Zurich, Conforti Frères (Martigny).

Generators : Maschinenfabrik Oerlikon (Zurich-Oerlikon) (two 50MVA, 16⅔ c/s, single-phase generators ; one 20MVA, 16⅔ c/s, single-phase generator ; one 22MVA, 50 c/s, three-phase generator).
AG Brown, Boveri & Cie. (Baden) (two 53·4MVA, 50 c/s, three-phase generators).

Transformers : S.A. des Ateliers de Sécheron (Geneva) (Seven single-phase transformers for forming two three-phase groups, each of 53MVA, 10/214-225-240-255kV, 50 c/s with one standby unit ; two regulating transformers, each of 13/72·3kV ± 13×1·5kV, 16⅔ c/s ; one single-phase transformer 20MVA, 13/149 ± 5kV/74·5 ± 2·5kV, 16⅔ c/s).
Maschinenfabrik Oerlikon (Zurich-Oerlikon) (one 22MVA, 50 c/s, three-phase transformer).

Transport of Heavy Equipment : A. Welti-Furrer AG (Zurich).

Sound Spectrometer

We are informed that Peekel Laboratorium voor Electronica N.V., Holland, have arranged for the manufacture in this country under licence of its model " GRB " sound spectrometer. The licensee is Advance Components, Ltd., Roebuck Road, Hainault, Ilford, Essex.

The instrument, which will be styled the " SPM 1," is stated to comply with the latest requirements laid down at the Rapallo Convention. Weighing only 9 lb and measuring 17in by 4·75in by 3·2in, it is a battery-operated, self-contained unit. It comprises a very small non-directional crystal microphone, six-stage amplifier stabilised by heavy feedback, eight bandpass filters which can be switched in at choice, and a moving-coil meter with a decibel scale. An attenuator is built in with five steps of 10dB covering a range of 30–80dB, together with an additional attenuator with three steps of 20dB covering a range of 0–60dB. Including the meter reading, the total range of the instrument is from 20dB to 150dB above the standard intensity level reference of 2×10^{-4} microbar $=2\times10^{-4}$ dyne per square centimetre over a range of frequencies from 20 c/s to 12,000 c/s which can be analysed into octave bands. The condition of the built-in batteries can be tested with the moving-coil meter.

Flexible Hacksaw Blade

We have received details of the U.M.V. flexible hacksaw blade made by Fl. Grobet, Vallorbe, Switzerland, and handled in this country by Sidney J. Jones, Ltd., 8, Balham Hill, London, S.W.12. The blades are manufactured from 2 per cent tungsten or high-speed steel in lengths of 8in, 10in, and 12in, and with the usual tooth pitches (fourteen, eighteen, twenty-four and thirty-two teeth per inch). A special process of manufacture leaves the body of the blade soft while the teeth are hardened. The result is a flexible blade which does not break.

Nordwestbogen Bridge

In our issue for January 6, page 17, we published a brief account of the Nordwestbogen bridge in Berlin. The design of this important structure is due to the firm Dyckerhoff and Widmann K.G. The company has pointed out that the amount of prestressing steel is 1800 tonnes, and not 924 tonnes as was stated in our article. The latter quantity refers to the plain reinforcement steel used in the foundations, piers, abutments and superstructure. It is also incorrect to refer to the prestressing members as " cables," as the " Dywidag " system employs individual round bars of special steel.

Fig. 12—Transport of rotor from Göschenen railway station to the power station

THE AMERICAN SCENE

By Our American Editor

Dresden Nuclear Power Station in Illinois

No. I

The Dresden nuclear power station of the Commonwealth Edison Company was formally dedicated at Morris, Illinois, 50 miles south-west of Chicago, on October 12, 1960. With a thermal output of 625·9MW and a generating capacity of 180MW, the station is believed to be the largest atomic power plant in the world. The power station was built by the General Electric Company at a cost of 45,000,000 dollars and employs the firm's dual-cycle boiling-water reactor. The initial reactor load comprises 65 tons of slightly enriched uranium fuel and is expected to last 3½ years. It is estimated that the new station will eventually produce power at a cost of 0·75 cent kilowatt-hour.

THE Dresden atomic power station is the first such installation in the United States to be financed in its entirety by private industry. It was designed and constructed by the General Electric Company, of Schenectady, New York, for the Commonwealth Edison Company of Illinois. Associated with the Commonwealth Edison Company in the venture is the Nuclear Power Group, Incorporated, consisting of the American Gas and Electric Company, Central Illinois Light Company, Illinois Power Company, Kansas City Power and Light Company, Pacific Gas and Electric Company, Union Electric Company of Missouri, and the Bechtel Corporation. The Bechtel Corporation was also the engineer-constructor for this station, providing design services for the conventional parts of the plant and all project construction services.

The site of the Dresden power station is approximately 50 miles south-west of Chicago, near the junction of the Des Plaines and Kankakee rivers. The reactor vessel and its associated equipment are housed in a 190ft diameter steel sphere. The large rectangular building to the left of the sphere in the photograph reproduced herewith contains conventional power plant components, such as the turbo-generator, condenser, feedwater heaters and control room. An administration building and access control building are situated in front of the turbine building. The dual-cycle boiling-water reactor uses light water, which passes through the reactor core of slightly enriched uranium dioxide and forms a steam-water mixture which is routed to a primary separating drum. The steam from this drum flows directly to the turbine at 965 lb per square inch gauge and 541 deg. Fah. Water from the drum is returned to the reactor through four secondary steam generators. Feedwater to these generators removes additional energy from the recirculating water to form secondary steam for admission to the turbine at 500 lb per square inch gauge and 461 deg. Fah. The reactor core is composed of 488 channel assemblies, each assembly having thirty-six fuel elements. The fuel is slightly enriched uranium dioxide in the form of pellets ½in in diameter and ½in long, encased in Zircaloy-2 tubing.

In the relatively new nuclear field, the successful completion of any large project such as the Dresden station requires an extensive test and development programme to provide basic design information and to develop a variety of specialised equipment and techniques. Such a programme was initiated early in the Dresden project. An important step in this programme and in confirming the boiling-water reactor concept was the successful operation of the Vallecitos Boiling-Water Reactor (V.B.W.R.) at the General Electric Vallecitos Atomic Laboratory near Pleasanton, California. This reactor, which was built to evaluate engineering, operating, and nuclear design aspects, was operated under stable conditions at full 5MW power. Also in operation at the Vallecitos Laboratory was a one-tenth scale critical assembly of the Dresden core. This assembly, which is housed in the Critical Experiment Laboratory, has provided considerable data which have confirmed the calculated characteristics for the full-scale Dresden core. The firm's Atomic Power Equipment Department headquarters at San José, California, in addition to office and manufacturing facilities, has several development buildings. One of these is an Engineering Test Facility, completed in 1956, which is being used to conduct heat transfer, fuel handling and fluid flow experiments. Also in San José is a Fuel Development Building, where work on the Dresden fuel assembly was performed.

Project History

The Dresden nuclear power station dates back to June 22, 1955, when the original contract between General Electric and the Nuclear Power Group was signed. The accompanying chart (Fig. 3) presents the pattern of the project schedules for the Dresden station. Following considerable initial study by the General Electric Company and the Bechtel Corporation, the design effort for the Dresden station was initiated in April, 1956, the final general design being approved in December, 1956. Detail design was essentially completed by December, 1958.

The procurement phase of the Dresden station involved the purchase of a large variety of

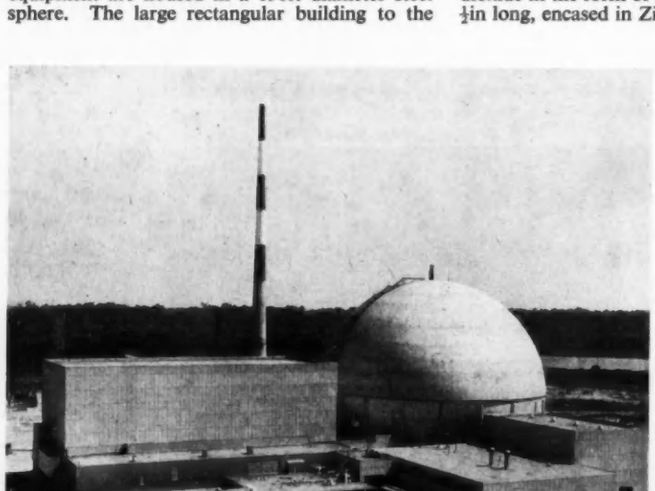


Fig. 1—180MW Dresden nuclear power station of the Commonwealth Edison Company in Illinois

Fig. 2—Engineering test reactor at the Atomic Power Equipment Department of General Electric in California

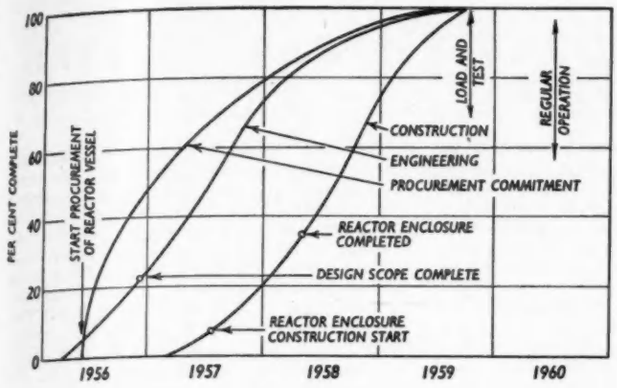


Fig. 3—Project schedule of the Dresden nuclear power station

materials and equipment. Procurement was initiated on May 29, 1956, with the placement of the purchase order for the reactor pressure vessel and the awarding of the sub-contract in June, 1956, for the erection of the reactor containment sphere. These two items were the major long-term delivery items affecting the construction of such a boiling-water nuclear plant. Approximately 90 per cent of the materials and equipment procurement was committed by June, 1958. Actual construction work began on March 1, 1957, with the initiation of the excavation for the reactor containment sphere and the turbine building foundations. As will be noted from Fig. 3, approximately 40 per cent of the design was complete at the start of construction and approximately 60 per cent of the procurement was committed. Construction work was completed on September 23, 1959. About 800 people were employed in the building of the plant. The project involved the use of approximately 57,000 cubic yards of concrete 3400 tons of reinforcing steel and 1400 tons of structural steel, exclusive of the 3500-ton steel sphere. The first nuclear chain reaction at Dresden was achieved on October 15, 1959. First electricity was produced on April 15, 1960, and full power was reached on June 29, 1960. The plant was placed in commercial operation on August 1, 1960, while the original scheduled completion date was December 8, 1960.

Thus, General Electric and Bechtel took a total of only thirty months to put up the largest atomic power station built so far in the United States. This remarkable achievement was made possible by the advantages of a "turnkey" contract, good union-labour relations and favourable weather at the site. The main contract gave General Electric the final say on all plant design and construction matters and reduced the number of signatures required to get things done. The smooth relations between Bechtel and the construction workers' unions meant that not a single day's work was lost because of union disputes, and the winter of 1957–58 remained ob.igingly mild while the Chicago Bridge and Iron Company was welding together the containment sphere. The most fundamental reason, however, was that the engineers of General Electric knew exactly what reactor they wanted to build and, in collaboration with their sub-contractors, had made thorough plans how to build it. The project engineers had enough head start with their supporting development work to supply definite answers for those problems which might have a serious influence on plant construction schedules before the schedules had to be fixed.

Typical of this planning, the major target dates for the construction phases were spelled out a full year ahead of the start of construction. To meet these dates, the project manager set up and enforced a rigid timetable for all the equipment, materials and services that were to become a part of the Dresden plant. The master schedule during construction listed more than 1000 tasks co-ordinated with respect to time and manpower. Every piece of plant equipment had its place on this list as well as such things as the areas where concrete was to be poured, reinforcing steel installed or electrical wiring laid. Even component-development work that continued in parallel with the construction had its place on this timetable. This included proof testing of the control rod drive, fuel-handling, hydraulic and fuel-rupture systems, some critical experiments and performance tests of the fuel elements at Vallecitos.

The only significant change in design to result from the parallel test programme was in the fuel-rupture location system. In March, 1959, it was found that proof tests at Vallecitos of the "sponge" rupture location system originally intended for Dresden would need more time for refinement than could be allotted for this part of the system. General Electric decided to replace this system with a more conventional sampling system in which tubes sample the coolant coming from each fuel element. To make this change at this stage of the construction, General Electric had to replace an 18in flange on the pressure vessel and run some stainless tubes into the hydraulic flow vane at the core inlet ; but by doing this work on overtime no construction time was sacrificed.

General Design

The Dresden nuclear power station is situated on a 950 acre site in the Grundy County of Illinois, at a point where the Kankakee and Des Plaines rivers meet to form the Illinois River. The station is approximately 50 miles south-west of Chicago, and 8 miles east of Morris, Illinois. The reactor site was formerly known as Dresden Heights, and there is an island in the Illinois River as well as a navigation lock named Dresden. The electrical output from the station is fed into the Commonwealth Edison interconnected grid network serving Chicago and northern Illinois. The technical characteristics of the power station are listed in Table I.

The most imposing physical feature of the Dresden plant is the 190ft steel sphere housing the reactor and auxiliary equipment making up the nuclear steam supply system. The sphere is the second largest of its kind in the world. The 300-ton reactor pressure vessel is situated in the centre of the sphere. A 300ft tall stack

Fig. 4—Construction site after completed erection of the 190ft diameter containment vessel

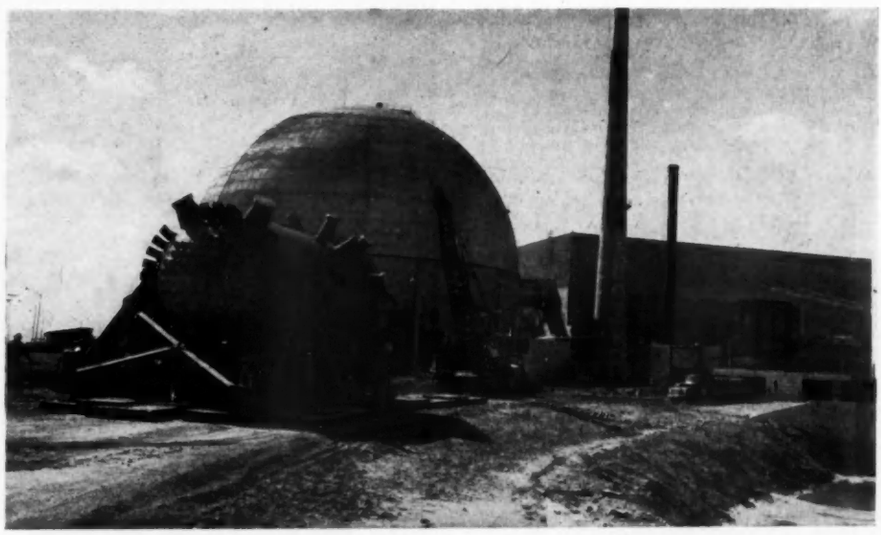


Fig. 5—Transfer into the containment sphere of the 300-ton reactor pressure vessel

THE AMERICAN SCENE *(continued)*

TABLE I—*Characteristics of Dresden Nuclear Power Station*

Location	Morris, Illinois
Designer	General Electric Company
Architect	Bechtel Corporation
Owner	Commonwealth Edison Company
Date critical	October 15, 1959
Output—Thermal	625,900kW
Electrical	180,000kW
Component Design Data :	
Pressure Vessel :	
Inside height	40·88ft
Inside diameter	12·17ft
Wall thickness	5·25–5·625in carbon) steel (A-302 Grade B
Cladding :	
Material	Stainless steel (Type 304L)
Thickness	0·375in (nominal)
Design pressure	1250 lb per square inch gauge
Test pressure	1875 lb per square inch gauge
Core :	
Configuration	Right cylinder
Size	10·7ft diameter by 11·2ft
Fuel load :	
U235	821 kg
U238	59·5 tons
Composition :	
Water	57 vol per cent
Uranium dioxide	27 vol per cent
Zircaloy	16 vol per cent
Control rods :	
Configuration	Cruciform
Number	Eighty
Composition	2 wt per cent B in Type 304 stainless steel
Total rod worth	14 per cent $\Delta k/k$
Weight	155 lb
Withdrawal rate	6in per second
Scram time	10 per cent stroke 0·6 sec 90 per cent stroke 2·5 sec
Fuel elements :	
Type	Pellet
Number	488
Enrichment	1·5 per cent
Rods per element	Thirty-six
Segments per rod	Four
Pellets per segment	Forty-three
Pellet dimensions	0·494 by 0·625in *
Pellet composition :	
Uranium	88·1 wt per cent
Oxygen	11·9 wt per cent
Pellet temperature (at rated load) :	
Average	1020 deg. Fah.
Maximum (centre) (rated)	4000 deg. Fah.
Cladding	Zircaloy-2
Control-rod drives :	
Type	Hydraulic
Number	Eighty
Working fluid	Reactor feedwater
Scram energy source	Accumulator†
Accumulator charge	1400 lb per square inch
Drive rate	6in/sec nominal
Nuclear Design Data :	
Moderator :	
Type	Light water
Average neutron energy	0·064 ev
Thermal flux, average	$3 \cdot 1 \times 10^{13}$ n/cm²/sec
Prompt-neutron lifetime	6×10^{-4} sec
Effective delayed-neutron fraction	0·0071
Moderation temperature coefficient	$1 \cdot 6 \times 10^{-4}$, $\Delta k/k$/deg. Fah.
Control requirement :	
Burnup	6 per cent $\Delta k/k$
Equilibrium Xe and Sm	4 per cent $\Delta k/k$
Doppler coefficient	1 per cent $\Delta k/k$
Voids	2 per cent $\Delta k/k$
Shutdown margin	3 per cent $\Delta k/k$
Total	16 per cent $\Delta k/k$ ‡
Heat-Transfer Data :	
Coolant (Primary system) :	
Type	Light water
Amount :	
In core	2774 gallons
Total	188 tons
Inlet flow	$25 \cdot 7 \times 10^6$ lb per hour
Inlet temperature	505 deg. Fah.
Outlet Steam :	
Temperature	547 deg. Fah.
Flow	1,405,000 lb per hour
Heat Flux :	
Maximum/average ratio :	
Axial	1·4
Radial	1·6
Core :	
Average	91,800 B.Th.U./hr/ft²
Maximum (rated)	280,000 B.Th.U./hr/ft²

* Two end pellets in each segment are of natural uranium 0·500in long.

† Or reactor pressure if above approximately 500 lb per square inch.

‡ Of this 16 per cent required, 14 per cent is supplied from control rods and 2 per cent from dysprosium poisoned end pellets.

was built for discharging ventilating air and process gases from the sphere. Adjacent to the sphere is the turbine building which houses the turbo-generator, main condenser, primary and secondary feed pumps, feedwater heaters, condensate demineraliser and the main control room. A separate building is used for the processing and storage of radioactive liquid wastes, while a fourth building is for the storage of new fuel, and for used fuel until it is returned to the A.E.C. for reprocessing.

The power source for the station is the General Electric dual-cycle boiling-water reactor, designed to produce about 630MW of heat. The reactor core contains nearly 66 tons of uranium dioxide fuel, which is expected to provide enough heat for full-power operation of the plant for 3½ years.

The fuel rods are clad with zirconium, a metal with excellent characteristics for use in a nuclear environment. The Dresden reactor is the first to use an entire loading of zirconium-clad fuel rods, and it is expected that much valuable information on the performance of zirconium will be gained from this pioneering effort. Fuel rods clad with the conventional stainless steel, and perhaps other metals, will be tried in the reactor later to compare their performance with that of zirconium. The reactor core is designed so that thirty-six additional fuel assemblies can be added to the reactor later when it becomes practical to do so, due to the build-up of "poisons" in the reactor system.

The reactor pressure vessel is 40ft high and 12ft 2in inside diameter. The walls of the vessel are carbon steel 5·5in thick, clad with stainless steel. Eighty stainless steel control rods containing 2 per cent boron are inserted into the core through the bottom of the reactor vessel. When power is being produced, water boiling inside the reactor core produces steam at 545 deg. Fah., at a pressure of 1000 lb per square inch. This wet steam rises through large pipes to a primary steam drum 67ft long and 7ft 11in inside diameter, where water is separated from the steam. The steam then is piped to the turbo-generator in the adjoining building. The hot water separated from steam in the primary steam drum flows into four secondary steam generators, 27ft high and 10ft in diameter, to produce additional steam at 467 deg. Fah. and at 500 lb per square inch.

(To be continued)

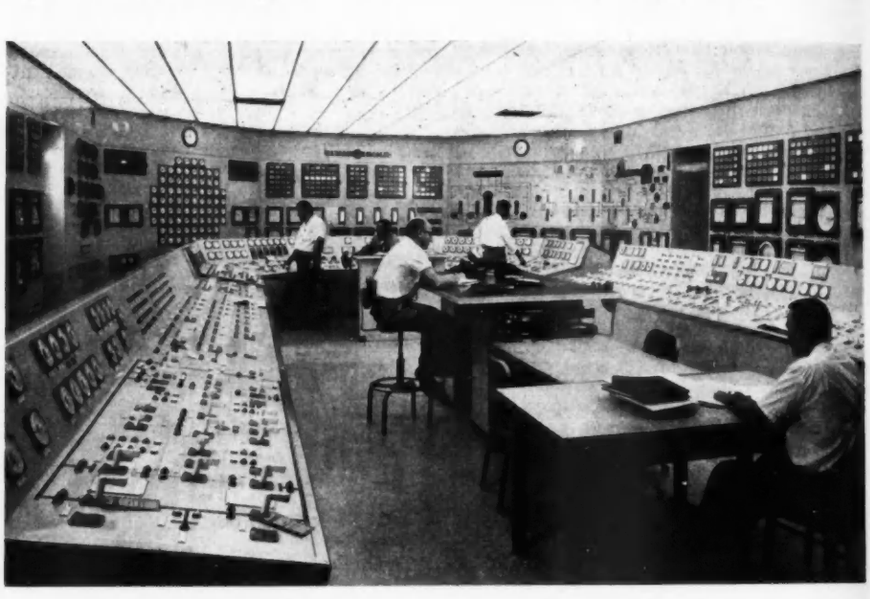


Fig. 6—Power station control room with complete nuclear controls and instrumentation

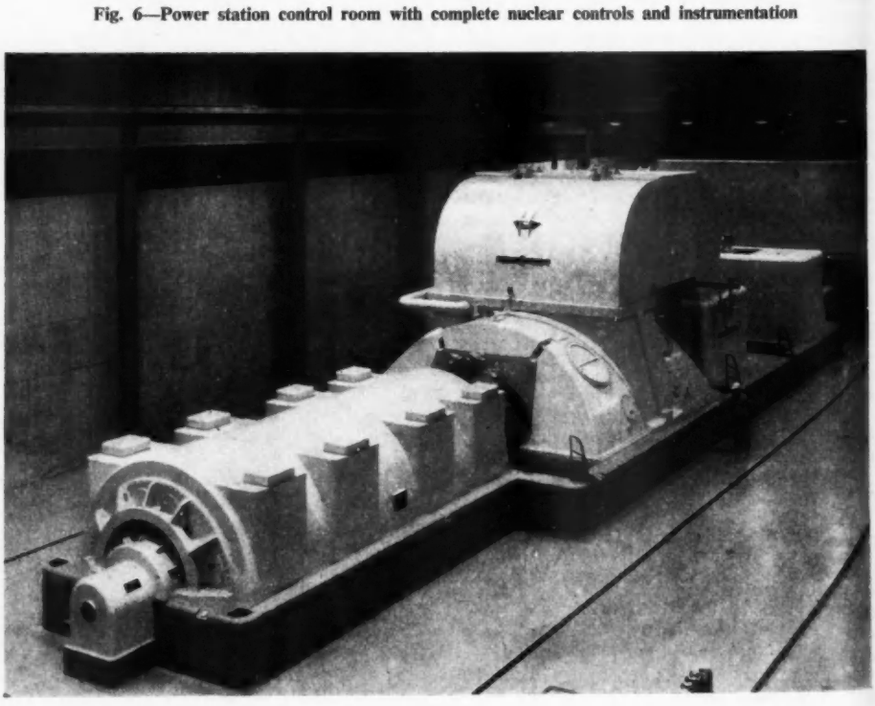


Fig. 7—192MW, 1800 r.p.m. General Electric three-cylinder tandem-compound turbo-generator

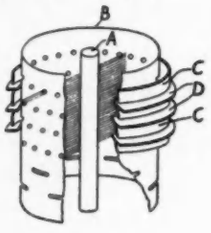
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

TELECOMMUNICATIONS

857,266. January 30, 1958.—GENERATION OF CARRIER FREQUENCIES, Tesla, Nardoní Podnik, 186, Podébradská, Prague IX, Czechoslovakia. (*Inventor : Vladimir Vachala.*)

In the design and construction of devices for multi-channel telephony it is necessary to produce a number of carrier frequencies which are harmonics of a very stable fundamental frequency. The methods which are applied in practice depend on the successful solution of the filter problem, because in all these methods the various frequencies have to be filtered out from a non-sinusoidal wave form. According to the invention, an electronic switch takes the form shown in the drawing. The whole switch is enclosed in an evacuated container, not shown. In its longitudinal axis is placed a cathode *A* around which is arranged a cylindrical screen *B*. This screen is surrounded on the outside by a stack of cylindrical anodes *C* and the screen is common to all these anodes. The anodes each have the shape of a short cylinder and between them are arranged grounded metallic screen rings *D*. The electrode system is located in a rotating magnetic field which is generated by two-phase or polyphase voltages or current. As can be seen from the drawing a row of openings is arranged in the screen opposite each anode *C*. The number of openings in each row depends on the frequency of the harmonic which has to be supplied by the respective anode. Electrons

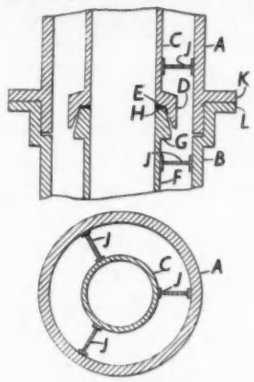


No. 857,266

emitted by the cathode in the instantaneous direction of movement of the rotating magnetic field form a flat electron beam, as shown in the drawing, which is rotated by the magnetic field and impinges upon the screen *B*. If the electrons fall upon openings in the screen, they pass through and impinge upon the respective anode *C* ; if the electrons do not meet a hole they are captured by the screen. Thus a regular impulse sequence is created on each anode, the frequency of this sequence being a function of the fundamental frequency of the rotating magnetic field and the number of openings in the respective row of the screen *B*. Depending on the shape of the openings provided in the screen it is possible to obtain harmonics of the fundamental frequency which are of approximately sinusoidal or any other shape, for instance, trapezoidal. Due to the fact that a separate anode is arranged opposite each row of openings in the screen *B*, the individual frequencies can be selected from the output without complicated and large filters.—*December* 29, 1960.

859,393. July 31, 1958.—WAVEGUIDE ANTENNA FEEDERS FOR PORTABLE RADIO SYSTEMS, Standard Telephones and Cables, Ltd., Connaught House, 63 Aldwych, London, W.C.2. (*Inventors : Alfred Charles Delamare and Joseph Paine.*)

The present invention relates to waveguide feeders for antennas in transportable radio communication systems. In transportable radio systems employing microwave frequencies, a waveguide feeder to an antenna mounted at the top of the mast is usual, but presents difficulties in a transportable system when the mast has to be built up from separate sections. Accordingly in some transportable systems the difficulty has been avoided by the use of a reflector arrangement in which a horizontal paraboloid antenna is used near the ground, and the microwaves are reflected thereto by a passive reflector mounted at the top of the mast. This arrangement has certain disadvantages, such as the necessity to transport, mount and accurately align an accurately profiled reflector in addition to the paraboloid, at both ends of the system ; and the fact that a horizontal paraboloid near the ground requires considerably more protection from the accumulation of snow and other debris than a vertical paraboloid mounted at the top of a mast. According to this invention, the advantages of the passive reflector system without its disadvantages are obtained by mounting the paraboloid antenna at the top of a mast built up from separate demountable sections, and coupling the antenna to the transmitting or receiving equipment by means of a waveguide also built up of separate sections, each of which sections is supported by a corresponding mast section. The drawings show axial and transverse sections of a demountable mast in the neighbourhood of a joint between two mast sections *A*, *B*. Inside the section *A* is



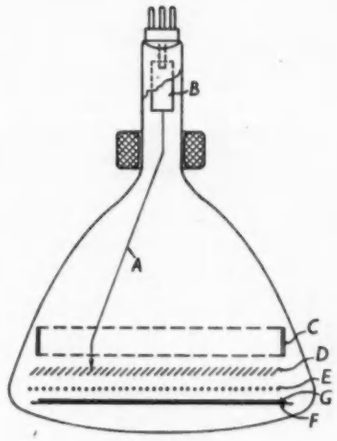
No. 859,393

mounted a section *C* of circular waveguide. The lower end of the waveguide terminates in a socket *D* having a conical internal face and an accurately machined annular seating *E* normal to the axis of the waveguide. Inside the tubular section *B* is mounted a waveguide section *F*, the upper end of which terminates in a spigot *G* having a conical external face and an accurately machined top rim *H* having an external diameter closely equal to that of the seating *E*. Waveguide sections *C* and *F* are secured inside the corresponding tubular sections of the mast by links *J* of spring material, or by any other suitable mechanical arrangement which allows a small resilient axial movement of the waveguide sections. When the mast is being built up, the spigot *G* at the upper end of the waveguide in a mast section already in place will be in such a position that when the next mast section is lowered into position, the surface *E* of the upper waveguide section comes into contact with the surface *H* of the lower waveguide section before the flanges *K* and *L* come into contact, so that the upper waveguide section is pushed upwards by a short distance (e.g. 1½in) against the resilient links *J* which thereby press the two waveguide sections together with an appreciable force, which may be of the order of three pounds weight. This automatically ensures that the internal surface of the waveguide is substantially continuous at the joints. It will be noted that the socket *D* acts as a shed to protect the joint from rain which may fall down the inside of the mast, so that no sealing gasket is necessary.—*January* 25, 1961.

ELECTRONICS

859,873. September 28, 1959.—COLOUR TELEVISION TUBES, Siemens and Halske Aktiengesellschaft, Berlin and Munich, Germany.

It is an object of this invention to provide a colour television tube of relatively simple construction which has only one electron beam and which reproduces the desired colour for the individual picture points on the whole picture area with high accuracy. In the drawing of the tube the path of an electron beam is indicated by a solid line *A*. The electron beam is created in a beam-generating system *B* in a conventional manner. By means of a cylindrical or conical electrode *C* in co-operation with the accelerator anode of the beam-generating system, the electron beam is slowed down, focused and bent into a direction parallel to the axis of the tube in such a way that it enters approximately perpendicularly the plane of a baffle grid *D* which is located behind it and which consists of a number of metal slats. On the rear side of this baffle grid is located a colour selection grid *E* consisting of electrically interconnected wires, and a short distance further, a translucent or transparent screen *F* which is provided with a layer *G* of strips of luminescent material. Either the screen or the layer may be provided with a conductive coating. A high-tension voltage is applied to the conductive coating in order to accelerate the electrons, which leave the baffle grid *D* and which have a low initial velocity, to the necessary final energy. In one colour selection method described in the specification, the



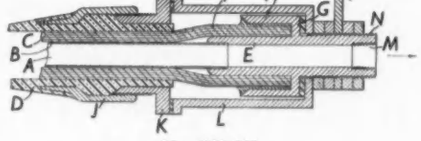
No. 859,873

electrons of the beam impinge on the baffle grid with a velocity corresponding to a voltage of 500V to 1000V in order to produce there as high a secondary emission as possible. The path of the secondary electrons from the baffle strips is deflected towards the screen by the electrical field between the baffle grid *D* and the conductive coating on the layer *G* or the screen *F*. The electrons are bunched in the process and are directed to a colour strip of the layer *G*, e.g. of the colour red under the additional influence of the colour selection grid *E*, which strip is arranged perpendicular to the plane of the drawing. By a change of the voltage applied to the colour selection grid, the effective electric field is changed and the secondary electrons are directed (focused) to the desired colour strip in accordance with this voltage.—*January* 25, 1961.

ELECTRICAL ENGINEERING

859,443. May 31, 1957.—ELECTRIC CABLE TERMINATIONS, Associated Electrical Industries, Ltd., 33, Grosvenor Place, London, S.W.1. (*Inventors: Eric Raymond Hartill, Norman Basil Hewett and Arthur William Pimm.*)

This invention is concerned with providing a termination for an electric power cable having a central duct for cooling fluid, the termination catering both for the cooling fluid and the electric current. Referring to the drawing, the cable has a central duct



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A carrying cooling fluid which is defined by walling *B* around which are wound stranded conductors *C* which in turn are covered by an insulating layer *D* of polythene. The termination comprises a member *E* of annular shape having the end portions *F* of the conductors secured around its external surface. Member *E* also has a lug *G* which projects laterally from the member and is formed with a depending skirt *H* so as to define an annular space between the skirt and the main portion of member *E*. The end portions *F* of the conductors are secured in this annular space and are sweated to the member. A metal gland nut *J* is bonded into the outer polythene layer of insulation and a threaded ring *K* is tightened thereon to form a sealed gland. To protect the joint between cable and termination an outer housing *L* is provided sealed at one end to ring *K* and the other end to lug *G* by means of gaskets. The housing is removable to enable the joint to be dismantled. Member *E* may be tapped internally at *M* to accommodate the necessary hose or tube to carry the cooling fluid. Thus the cooling fluid is taken straight out of the cable in order to avoid bends in the flow path which would increase the pressure required to force the fluid through the cable. The member *E* is also threaded externally at *N* to provide an electrical connection for a current take-off lead *P* at right angles to the cable.—*January* 25, 1961.

Catalogues and Brochures

TURNERS ASBESTOS CEMENT COMPANY, Ltd., Trafford Park, Manchester, 17.—Illustrated booklets dealing with "Everite" extractors and ventilators; "Everite" asbestos-cement baffle boxes, dip, scum and weir plates for sewage work; "Pollite" textured flat asbestos-cement sheets for interior and exterior application; "Turnall" Granitone decorated asbestos-cement sheets for interior and exterior application; and "Everite" "Bigsix" asbestos-cement corrugated sheets.

THE VISCO ENGINEERING COMPANY, Ltd., Stafford Road, Croydon.—Brochure No. 604 entitled "Visco Dust Collection" which supersedes publication No. 574 "Modern Dust Collection" published in 1957. The brochure contains sections on "Cyclone Dust Collectors," "Cyclocell Multi-Tubular Collector," "Textile Sleeve Dust Collectors," "Fully Automatic Visco-Beth Dust Collector," "Combined Frame Extraction and Dust Recovery Plant," and "Visco-Handte Wet Type Dust Collector."

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Feb. 17.—STOKE AND CREWE BRANCH: Grand Hotel, Hanley, "Light as an Aid to Industrial Production," T. Catten, 7.30 p.m.

Mon., Feb. 20.—BRISTOL AND WEST OF ENGLAND BRANCH: Grand Hotel, Bristol, "Earthing," P. W. Cave, 8 p.m.

Tues., Feb. 21.—NATIONAL EVENT: I.E.E. Lecture Theatre, Savoy Place, London, W.C.2, "Operation of Electrical Plant in Hazardous Areas," W. J. F. Cocks, 6.30 p.m. ★OXFORD AND DISTRICTS BRANCH: Employment Exchange, Oxford, "About the Supergrid," H. B. Dreyfus, 8 p.m.

Thurs., Feb. 23.—SOUTH LONDON BRANCH: Greyhound Hotel, High Street, Croydon, Surrey, "Transistors," 8 p.m. ★NORTHERN IRELAND CENTRE: Central Hall, Rosemary Street, Belfast, "The Transistor—Principles of Operation, Manufacture and Applications," F. Szekely, 7.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Feb. 22.—MEDICAL ELECTRONICS GROUP: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, Discussion on "Transistorised Medical and Biological Electronic Equipment," 5.30 p.m. ★SOUTHERN SECTION: Lanchester Building, The University, Southampton, "The Application of Computers to Commercial Problems," N. D. Hill, 7 p.m.

Fri., Feb. 24.—SOUTH MIDLANDS SECTION: North Gloucestershire Technical College, Cheltenham, "Design Aspects and Characteristics of Long Distance Waveguide Communication Systems," A. E. Karbowiak, 7 p.m.

CEMENT AND CONCRETE ASSOCIATION

Mon., Feb. 20.—Institute of Technology, Great Horton Road Bradford, "The Essentials of Good Concreting," E. E. H. Bate, 7.15 p.m.

Wed., Feb. 22.—West Wiltshire and Trowbridge College of Further Education, College Road, Trowbridge, "Structural Properties of Lightweight Aggregate Concrete," G. H. Newton, 7.15 p.m.

Mon., Feb. 27.—Cambridgeshire Technical College and School of Art, Collier Road, Cambridge, "Surface Finishes of Concrete," F. Ward, 7.30 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., Feb. 21.—SOUTHERN REGION: Criterion Restaurant, Piccadilly, London, W.1, Discussion on "Problems of the Packaged Boiler," opened by A. Wilson, 10.30 a.m.

Wed., Feb. 22.—MIDLAND REGION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, Discussion on "Preparation and Handling of Coal and Ash in Small Boiler Plant," opened by E. Otty and W. G. Archer, 10.30 a.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Feb. 20.—LEEDS CENTRE: British Lighting Council, 24, Aire Street, Leeds, 1, Presidential Address, W. S. Stiles, 6.15 p.m.

Tues., Feb. 21.—LIVERPOOL CENTRE: Electrical Industrial Development Centre, Merseyside and N. Wales Electricity Board, Paradise Street, Liverpool, 1, "Lighting of Niagara Falls," D. J. Reed and T. D. Proctor, 6 p.m.

Thurs., Feb. 23.—LEICESTER CENTRE: Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, "Basis of Recommended Illumination Levels in Britain and the U.S.A.," A. W. Marsden, 6.15 p.m.

Mon., Feb. 27.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, Annual General Meeting, "Plastics for Lighting," W. E. Harper and "Glass for Lighting," J. G. Holmes, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Mon., Feb. 20.—EAST ANGLIAN SECTION: Lecture Hall, Public Library, Ipswich, "Developments in the Production of Gunmetal Castings," F. Hudson, 7.30 p.m.

Wed., Feb. 22.—LONDON SECTION: Constitutional Club, Northumberland Avenue, London, W.C.2, "Production and Applications of Spheroidal-graphite Iron Castings in a General Engineering Firm," H. Turner and P. Savage, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Feb. 20.—WEST OF ENGLAND SECTION: Small Engineering Lecture Theatre, The University, University Walk, Bristol, 8, Annual General Meeting, 7.30 p.m.

Tues., Feb. 21.—SOUTHERN BRANCH: Technical College, Portsmouth, Joint meeting with the Southern Branch of the Royal Institution of Naval Architects, "Machinery Induced Vibrations," A. J. Johnson and W. McClimont, 7.30 p.m. ★JUNIOR LECTURE: Borough Polytechnic, Borough Road, London, S.E.1, "Boiler Water Treatment," C. J. Hasler, 7.15 p.m.

Wed., Feb. 22.—WEST MIDLANDS SECTION: Engineering Centre, Birmingham, "Development of Medium Speed Diesel Engines for Marine Auxiliary Uses," C. J. Hind, 7 p.m. ★JUNIOR LECTURE: Willesden Technical College, Willesden, "The Layout and Operation of Marine Steam Turbine Machinery," D. M. V. Parkinson, 2.15 p.m. ★KINGSTON-UPON-HULL AND HUMBER AREA SECTION: College of Technology, Park Street, Kingston-upon-Hull, "Marine Lubrication," C. A. Gaskin, 7.30 p.m.

INSTITUTE OF METALS

Wed., Feb. 22.—MANCHESTER METALLURGICAL SOCIETY: Manchester Literary and Philosophical Society, George Street, Manchester, "Metallurgical Applications of Radioisotopes," M. C. Inman, 6.30 p.m.

INSTITUTE OF NAVIGATION

To-day, Feb. 17.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, Discussion on "The Admiralty Chart—II," 5.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Feb. 21.—NORTH EASTERN CENTRE: Three Tuns Hotel, Durham City, "Diesel Power Units," D. Kaberry, 7 p.m.

Thurs., Feb. 23.—NORTHERN CENTRE: Commercial Hotel, Accrington, "Recent Developments in Automotive Diesel Engines," 7.30 p.m.

Mon., Feb. 27.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "Wheels Round the World," 7.30 p.m.

INSTITUTE OF SEWAGE PURIFICATION

Wed., Feb. 22.—MIDLAND BRANCH: James Watt Institute, Great Charles Street, Birmingham, 3, Lecture and film on "Sewage Works in Russia," D. H. A. Price, 2.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Feb. 21.—NORTH WESTERN BRANCH: Chemical Engineering Lecture Theatre, Manchester College of Science and Technology, Jackson Street, Manchester, 1, "Floating Cap Trays for Absorption and Distillation," W. S. Norman, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 21.—JAMES FORREST LECTURE: Great George Street, Westminster, London, S.W.1, "Elastic Theory and Engineering Structures," A. J. S. Pippard, 5.30 p.m.

Tues., Feb. 28.—Great George Street, Westminster, London, S.W.1, "Some Experiences with Prestressed Concrete Piles," S. V. Gardner and D. H. New, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Feb. 17.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, "A Comprehensive Introduction to Plasma Physics," W. B. Thompson, 5.30 p.m.

Sat., Feb. 18.—LONDON GRADUATE AND STUDENT SECTION: Visit to B.B.C. Tatsfield Receiving and Measuring Station, Tatsfield, Kent, 2.15 p.m.

Mon., Feb. 20.—LONDON GRADUATE AND STUDENT SECTION: Savoy Place, London, W.C.2, "Testing High Voltage Interconnected Systems with Particular Reference to the Kariba Scheme," K. M. Jones, 6.30 p.m. ★MERSEY AND NORTH WALES CENTRE: Town Hall, Chester, Third Hunter Memorial Lecture, "The Application of Electronics to the Electricity Supply Industry," J. S. Forrest, 6.30 p.m. ★NORTH-EASTERN MEASUREMENT AND ELECTRONICS GROUP: Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne, Fifty-First Kelvin Lecture, "Cosmic Radiation," C. F. Powell, 6.15 p.m. ★SHEFFIELD SUB-CENTRE: Angel Hotel, Brigg, "Operating Experience at Calder Hall," K. L. Stretch, 6.30 p.m. ★WESTERN SUPPLY GROUP: South Wales Institute of Engineers, Park Place, Cardiff, "Short-Circuit Ratings for Mains Cables," G. S. Buckingham, and "A Basis for Short-Circuit Ratings for Paper-Insulated Cables up to 11kV," L. Gosland and R. G. Parr, 6 p.m.

Tues., Feb. 21.—MEASUREMENT, SUPPLY AND UTILISATION SECTIONS: Savoy Place, London, W.C.2, "Sphere-Gaps;" "Influence of Humidity on the Breakdown Voltage of Sphere-Gaps and Uniform Field Gaps;" "The Direct-Voltage Calibration of Air-Gaps in a Uniform Field and between Spheres up to 25cm in Diameter with Recommendations for Standard Test Conditions;" "The Effect of Irradiation on the Breakdown Voltage of Sphere-Gaps in Air under Direct and Alternating Voltages," E. Kuffel, and "The Influence of Nearby Earthed Objects and of the Polarity of Voltage on the Direct Voltage Breakdown of Horizontal Sphere-Gaps," E. Kuffel and A. S. Husbands, 5.30 p.m. ★NORTH MIDLAND UTILISATION GROUP: Leeds and County Conservative Club, South Parade, Leeds, 1, "The Application of Power Transistors to the Operation of Gas-Discharge Lamps from D. C. Supplies," I. F. Davies and D. Dunthorne, 6.30 p.m. ★NORTH-WESTERN MEASUREMENT AND CONTROL GROUP: Engineers' Club, Albert Square, Manchester, "Precision Measurement," G. H. Rayner and A. Felton; "Improvements in the Precision Measurement of Capacitance," G. H. Rayner and L. H. Ford; "The Design of an Audio-Frequency Amplifier for High-Precision Voltage Measurement," S. Harkness and F. J. Wilkins; "The Design and Performance of High-Precision Audio-Frequency Current Transformers," J. J. Hill and A. P. Miller, and "Techniques for the Calibration of Standard Current Transformers up to 20 kc/s," J. J. Hill, 6.15 p.m. ★SOUTH-EAST SCOTLAND SUB-CENTRE: Carlton Hotel, Edinburgh, "British Nuclear Power To-day," A. L. Shaw, 7. p.m.

Wed., Feb. 22.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, "Coding Theory and its Applications," J. M. Meggitt, 5.30 p.m. ★LONDON GRADUATE AND STUDENT SECTION: Visit to the B.P. Refinery (Kent), Ltd., Isle of Grain, 9 a.m. ★EAST MIDLAND CENTRE: George Hotel, Kettering, "Telecommunications—Modern Developments," N. Fox and D. D. Wright, 7.30 p.m. ★SOUTH-WEST SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Radiocommunication in the Power Industry," E. H. Cox and R. E. Martin, 6 p.m. ★SOUTHERN CENTRE: The University, Southampton, Joint meeting with the Royal Aeronautical Society, "Aircraft Electrical Power Systems," H. Zeffert and J. P. Ratcliffe, 7 p.m.

Thurs., Feb. 23.—EAST MIDLAND CENTRE: Lecture Theatre, Portland Building, The University, Nottingham, Joint meeting with the East Midlands Branch of the Institution of Mechanical Engineers, "Design of a Defensive Guided Missile," J. A. Robinson, 6.30 p.m. ★WESTERN UTILISATION GROUP: South Wales Electricity Board Demonstration Theatre, Kingsway, Swansea, "The Development of the Magnetic Particle Clutch including reference to its Industrial and Automotive Applications," E. G. Barratt, 6 p.m.

INSTITUTION OF ENGINEERS-IN-CHARGE

Wed., Feb. 22.—British Lighting Council, Brettenham House, Lancaster Place, London, W.C.2, "Recent Developments in Industrial Lighting Practice," G. B. Durham, 6.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Feb. 17.—NORTH EASTERN BRANCH: Cleveland Scientific and Technical Institution, Middlesbrough, "Current Trends in Foundation Design and Construction," 7 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Tues., Feb. 21.—Lecture Hall, Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, S.W.1, "The Collection and Assessment of Technical Information, including the Language Problem," Joan Ritchie, and B. R. Byrne, 5.30 p.m

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 17.—WESTERN BRANCH: Rougemont Hotel, Queen Street, Exeter, Informal discussion 7 p.m.

Mon., Feb. 20.—NUCLEAR ENERGY GROUP: 1, Birdcage Walk, Westminster, S.W.1, "The Influence of Availability of Enrichment on Reactor Type and Design," opening speaker, J. R. Smith, 6 p.m. ★DERBY A.D. CENTRE: Midland Hotel, Derby, "Non-Destructive Testing of Aero-engine Components," W. G. Cook, 7.30 p.m. ★SCOTTISH A.D. CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Some Design Features of a Diesel Engine for Use in Earth Moving Equipment," F. R. Porter, 7.30 p.m.

Tues., Feb. 21.—SOUTH WALES BRANCH: Kingsway Demonstration Theatre, South Wales Electricity Board, Swansea, Repetition of the Thomas Lowe Gray Lecture, "The Early Development of the Dracone Flexible Barge," W. R. Hawthorne, 6 p.m. ★COVENTRY GRADUATES' A.D. SECTION: Grosvenor Room, Hotel Leofric, Coventry, "Air Conditioning in Automobiles," N. J. Scutter, 7.30 p.m.

Wed., Feb. 22.—THOMAS HAWKSLEY LECTURE: 1, Birdcage Walk, Westminster, London, S.W.1, "Controlled Fusion Reactions," P. M. S. Blackett, 6 p.m. ★EAST MIDLANDS GRADUATES' BRANCH: College of Technology and Commerce, Leicester, Ladies Evening Film Show, 7.15 p.m. ★LONDON GRADUATES' BRANCH: Joint visit with the Graduates' Sections of the Institutions of Civil and of Electrical Engineers, to the B.P. Refinery (Kent), Ltd., Isle of Grain, 9 a.m. ★SOUTHERN GRADUATES' BRANCH: Technical College, Reading, "Refrigeration," 7. 30 p.m.

Thurs., Feb. 23.—LONDON BRANCH: The University, Sheffield, "The Performance of Forging Presses," H. Stern and J. I. T. Green; "The Mechanism of Lubrication in Cold Rolling," J. M. Thorp, and "A Formula for Spread in Hot Flat Rolling," L. G. M. Sparling, 6.30 p.m. ★EAST MIDLANDS BRANCH: Portland Building, The University, Nottingham, "Design of a Defensive Guided Missile," J. A. Robinson, 6.30 p.m. ★NORTHERN IRELAND BRANCH: Kensington Hotel, Belfast, "The Production of Iron and Non-Ferrous Castings for the Heavy Engineering Industry," E. Nelson, 6.45 p.m. ★NORTH-WESTERN BRANCH: Engineers' Club, Albert Square, Manchester, Repetition of the James Clayton Lecture, "Future of Air-Breathing Engines in Aviation," S. G. Hooker, to be read by A. V. N. Reed, 6.45 p.m. ★SOUTHERN BRANCH: Technical College, Brighton, "Teaching Metallurgy to Engineers," J. G. Ball, 7.30 p.m. ★EASTERN GRADUATES' BRANCH: Visit to Colchester Lathe Co., Colchester, 7.30 p.m. ★LONDON GRADUATES' BRANCH: Visit to Hoover, Ltd., Western Avenue, Greenford, Middlesex. 2.15 p.m. ★NORTHERN IRELAND GRADUATES' BRANCH: Georgian Rooms, May Street, Belfast, "The Production of Iron and Non-Ferrous Castings for the Heavy Engineering Industry," E. Nelson, 7 p.m.

Fri., Feb. 24.—EAST MIDLANDS GRADUATES' BRANCH: Visit to Metalastick Ltd., Evington Valley Road, Leicester, 7 p.m. ★NORTH WESTERN GRADUATES' BRANCH: Visit to Agecroft Power Station, Manchester, 7 p.m.

Sat., Feb. 25.—MIDLAND GRADUATES' BRANCH: Visit to British Oxygen Gases, Ltd., Wolverhampton, 9.45 a.m. ★COVENTRY GRADUATES' A.D. SECTION: Visit to Hams Hall 'C' Power Station, Lea Marston, Sutton Coldfield, 10 a.m.

INSTITUTION OF PLANT ENGINEERS

Thurs., Feb. 23.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, Branch Annual General Meeting and Case Studies, 7.30 p.m.

Fri., Feb. 24.—WESTERN BRANCH: Grand Hotel, Broad Street, Bristol, Ladies' Night, 7.15 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Feb. 20.—NORTHERN REGION: Connaught Hall, Blackett Street, Newcastle upon Tyne, "The Design of Bluebird," D. Stevens, 7 p.m.

Tues., Feb. 21.—NORTH WESTERN REGION: Grand Hotel, Hanley, Stoke-on-Trent, Annual General Meeting, and "Production and Manufacture of Gears," R. Hepper, 7 p.m. ★EAST AND WEST RIDINGS REGION: Lecture Theatre, Engineering Tower, Technical College, Huddersfield, Annual General Meeting and "Lubrication Problems on Machine Tools," G. M. Brown, 7 p.m.

Wed., Feb. 22.—MIDLANDS REGION: New Technical College, London Road, Shrewsbury, "Production Planning and Control by Computer," 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

To-day, Feb. 17.—LEICESTER SECTION: Royal Hotel, Leicester, "The Organisation of a Technical Department," J. A. Hardman, 7.30 p.m.

Mon., Feb. 27.—Engineers' Club, Albert Square, Manchester, "Properties and Applications of Chlorobutyle," P. E. C. Davies, 6.45 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Feb. 17.—SCOTTISH BRANCH: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Development of Nuclear Power in the United Kingdom," T. C. Waters, 7 p.m.

Tues., Feb. 21.—WALES AND MONMOUTHSHIRE BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, "Economics of Framed Structures," L. R. Creasy, 6.30 p.m.

Fri., Feb. 24.—MIDLAND COUNTIES BRANCH: Byng Kendrick Suite, College of Advanced Technology, Gosta Green, Birmingham, 6, "Computers and Structural Design—the Present Position and Future Trends," R. E. Rowe, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 17.—INFORMAL MEETING: Pepys House, 14, Rochester Row, Westminster, S.W.1, "Bioengineering," H. S. Wolff, 7 p.m.

Fri., Feb. 24.—Pepys House, 14, Rochester Row, Westminster, S.W.1, "Traffic Engineering in Urban Areas," J. T. Duff, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Feb. 24.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, "Fatigue Strength of Marine Shafting," G. P. Smedley, and B. K. Batten, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Thurs., Feb. 23.—WEST OF ENGLAND BRANCH: New School of Engineering, The University, Bristol, "Model Analysis of Structures," R. E. Rowe, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Feb. 21.—Lecture Theatre, 4, Hamilton Place, London, W.1, "Newer Metallic Materials of Construction," N. P. Inglis, 7 p.m.

ROYAL INSTITUTION OF GREAT BRITAIN

Fri., Feb. 24.—21, Albemarle Street, London, W.1, "Radio Astronomy and Cosmology," Martin Ryle, 9 p.m.

ROYAL INSTITUTION OF NAVAL ARCHITECTS

Tues., Feb. 28.—Institute of Marine Engineers, 76, Mark Lane, London, E.C.3, "Lloyds Rules for a Nuclear Ship," J. M. Murray, and H. N. Pemberton, 5.30 p.m.

ROYAL SOCIETY

Thurs., Feb. 23.—Burlington House, Piccadilly, London, W.1, "Some Recent Developments at the National Physical Laboratory," Sir Gordon Sutherland, 4.30 p.m.

ROYAL SOCIETY OF ARTS

Wed., Feb. 22.—John Adam Street, Adelphi, London, W.C.2, "Geography and the Business World To-day," Rt. Hon. Lord Nathan, 6 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Feb. 28.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, Cathodic Protection Panel Meeting, "External Protection of Floating Craft," M. G. Duff and P. Clark, 6 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Feb. 28.—Manson House, 26, Portland Place, London, W.1, "Three Terminal Bridge Measurements and Automation," V. S. Griffiths, 6.30 p.m.

TELEVISION SOCIETY

Thurs., Feb. 23.—Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2, "Programme Problems and Possibilities Associated with 'Monitor'," Huw Wheldon, 7 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Feb. 24.—39, Elmbank Crescent, Glasgow, Joint meeting with the Engineers' Group, Iron and Steel Institute, "Layout and Design of a Hot Strip Mill," M. F. Dowding, C. Sturdy and A. A. Thomas, 6.45 p.m.